MILITARY PROCUREMENT OF AIR NAVIGATION EQUIPMENT

HEARINGS

BEFORE A

SUBCOMMITTEE OF THE COMMITTEE ON GOVERNMENT OPERATIONS HOUSE OF REPRESENTATIVES

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MILITARY PROCUREMENT OF AIR NAVIGATION EQUIPMENT

TUESDAY, MARCH 1, 1955

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON MILITARY OPERATIONS,
OF THE COMMITTEE ON GOVERNMENT OPERATIONS,
Washington, D. C.

The subcommittee met, pursuant to adjournment, at 10 a. m., in room 1501, New House Office Building, Hon. Chet Holifield presiding.

Present: Representatives Holifield (presiding), Griffiths, Fascell, Kilgore, Lipscomb, and Riehlman.

Also present: Michael P. Balwan, staff director; Earl J. Morgan, investigator; and James F. Eckhart, assistant counsel.

Mr. HOLIFIELD. The subcommittee will be in order.

We have been informed by Mr. Balwan, our staff director, that Mr. Morrow has a statement that he wishes to make in regard to TACAN. We would like to hear you this morning, Mr. Morrow. As this matter will possibly involve some witnesses from the other side of the case, we would like to place you under oath for the purpose of hearing your testimony. We will hear you first, Mr. Morrow.

TESTIMONY OF COLE H. MORROW, REPRESENTING THE NATIONAL BUSINESS AIRCRAFT ASSOCIATION

(Mr. Cole H. Morrow, being first duly sworn, testified as follows:)

Mr. HOLIFIELD. Mr. Morrow, you may proceed to give us your statement. Please remember that this subcommittee is going into this difficult subject rather completely, so try to make a chronological presentation of the case in such a manner that, even though we have a difficult subject, we will get some idea of what you are talking about.

Could I ask you, first, to give your name for the record and tell us whom you represent?

Mr. BALWAN. State your full name for the record.

Mr. MORROW. My name is Cole H. Morrow, and I am representing the National Business Aircraft Association, which is an organization of corporations and business concerns who own and operate airplanes as an adjunct to their business.

Before I get into the TACAN situation, I should like to present a little historical background, to describe how we get down to the point we have reached today in this controversy. In 1947, the so-called "common" system of air navigation was established; that is, a joint usage of facilities by civil and military aircraft. A special committee—No. 31, it was called—of the Radio Technical Commission for Aeronautics, outlined and blueprinted the common system. This was

participated in and agreed to by all the military agencies and all the civil agencies. It was a unanimous agreement. As a matter of fact, the Collier award was presented to the Radio Technical Commission for Aeronautics, for their work in establishing and blueprinting the so-called "common" system.

Mr. HOLIFIELD. What was the name of this system, and what was its purpose, please?

Mr. MORROW. Well, it was not a system, in that it was a device, but it was the complete integration of military operating requirements and civil operating requirements, so that instead of having 2 systems, we would have only 1.

Mr. BALWAN. A system to do what?

Mr. HOLIFIELD. The purpose of it was to do what?

Mr. MORROW. To integrate and control air traffic—to integrate aircraft and to maintain traffic control.

Mr. HOLIFIELD. By visual aids, such as the radiobeacon?

Mr. MORROW. Well, by the use of modern radiobeacons and all kinds of devices, together with general operating specifications of the equipment that would be used, which would also be outlined and established, specifying just what the equipment was to do, its functions, and its operating characteristics, and so forth.

Mr. BALWAN. This was a kind of pact, wasn't it, between the civil aviation people and the military, that they would use specific means for developing it——

Mr. MORROW. That they would all try to achieve this.

Mr. BALWAN. That is, through the recognition of common difficulties and the use of a common system?

Mr. MORROW. That is right. Obviously there are many different pieces of equipment making up this system, and one of the pieces of equipment today—one navigating system was the VOR–DME, a combination which provides azimuth and distance from known locations on the ground. At the time the committee was considering the various navigation statements.

Mr. BALWAN. What committee is this, that you are talking about?

Mr. MORROW. SC–31, the basic principles. The distance portion of TACAN was presented to that committee, and it was actually turned down.

Mr. HOLIFIELD. This was an opposing system, a system in opposition to the VOR–DME?

Mr. MORROW. Well, at that time it was proposed as the distance portion of the common system, in lieu of what we now know as the VOR–DME.

Mr. HOLIFIELD. And who proposed it?

Mr. MORROW. It was proposed by representatives of the Navy.

Mr. BALWAN. This was before anyone had been committed to the present VOR–DME, was it?

Mr. MORROW. Before that system had been devised.

Mr. KILGORE. May I ask a question? Is the distance feature of this system a matter of triangulation?

Mr. MORROW. No.

Mr. KILGORE. Or is it a matter of radar?

Mr. MORROW. It is a form of radar, and it is a transmitted radio signal. The aircraft sends out a signal, and there is a transponder

on the ground which sends out the signals, and the equipment in the aircraft measures the timelag and converts that into distance information.

Subsequently, as the implementation of the common system program, as outlined by SC–31 was proceeding, the Federal Telegraph Communications Corporation made such a fuss about the distance component, the distance equipment, that a special committee, No. 40, Radio Technical Assistance for Aeronautics, was formed, to resolve this controversy as to whether we should use the principles which are now incorporated in TACAN, or whether we should use another principle, which had been adopted for the common system distance item. Again, the really imaginary feature, which is the technical term that the argument was about, was again thrown out, and we proceeded with the implementation of our entire United States, with what we now have as the common system, DME. And, by the way, all of the military agencies, the Air Force, the Navy, the Coast Guard, and the Army, as well as all the civilian people, participated in all of the coordination committeees, and unanimously agreed to adopt the distance portion of the common system, as well as VOR, which is the azimuth portion.

Mr. BALWAN. Who was on the committee, SC–40?

Mr. MORROW. I could not recall those names.

Mr. BALWAN. I mean what agencies. Or did you just mention those?

Mr. MORROW. There were the Navy and the Air Force, the Air Transport Association. That was in 1949. So I know it was composed of technical representatives from some of the civil agencies—I think Aeronautical-Radio, Inc., as well as—I know it had representatives from Hazeltown Electronics Corp.

Mr. BALWAN. Were you a member?

Mr. MORROW. No, I was not.

Mr. BALWAN. I think that answers my questions.

Mr. HOLIFIELD. All right.

Mr. MORROW. After all of these technicalities of the system, the operating characteristics of the system, had been unanimously agreed to, we have proceeded with the implementation of a complete nationwide network of stations, and they are presently operating. However, the Navy proceeded with the development of TACAN, and they claimed the basis on which they had to proceed with this development was, that they required a homing device for use aboard carriers; and the reason that they justified the continuance of development was (1) they had to have a system that was secure, that would not provide intelligence to the enemy. As I think you can see, if they have a carrier out in the ocean and it is transmitting navigational signals to its own aircraft, it must be of such a nature that the enemy cannot likewise use it, to navigate right to that carrier.

The other reason—and these are the only two reasons that were ever in the picture, until at least a year or year and a half ago—was the storing and so on.

VOR–DME was too large to be installed in enough places.

Mr. BALWAN. When did you learn that the Navy was developing TACAN?

Mr. MORROW. Well, we heard of its starting in 1951. We only heard of it. It was like a ghost, it was so highly classified and secret that

we knew they were developing a device for homing on carriers. We didn't know what its characteristics were, or anything about it. There were people, however, in the Air Navigation Development Board who were familiar with its characteristics, and I think in 1950 the Air Force was not in agreement with the Navy's development. The Navy was trying to get the Air Force to adopt TACAN as their short-distance aid to navigation, too; but the Air Force didn't go along. They said that they had to be a part of the common system, and the common system navigational aid had to be the Air Force aid.

Mr. BALWAN. In talking about TACAN, are you talking about an item, a system, or about an actual box that was functioning at that time?

Mr. MORROW. Well, it was a box that was functioning at that time. It was nothing more than an electronic device which it was proposed would do all of these things—in other words, all of its operating characteristics were merely proposals or claims. I do not think that it was its actual performance. In other words, I don't think they had a working prototype.

Mr. KILGORE. If I may ask a question——

Mr. HOLIFIELD. Certainly.

Mr. KILGORE. Are both of these systems line-of-sight transmissions?

Mr. MORROW. Yes, sir.

Mr. KILGORE. So that insofar as their limitations with respect to their range of navigation are concerned, there would be no advantage in either one?

Mr. MORROW. Well, yes; there are a lot of technical problems that become involved, while they are basically learning the form of transmission that TACAN system uses—wave-propagation features, which we cannot apply in civil operation, as a matter of safety. It is subject to a shadow, it is subject to reflections, to which our VOR–DME system is not. It operates in the 1,000 megacycle range. For example, if a TACAN station on the ground is installed near a wire fence, the wire fence will act as an electronic reflector and will cause errors in the azimuth readings, so that in order to avoid those errors it is necessary that TACAN ground stations be installed on a 100-foot high tower. We do not think that a 100-foot high tower is a practical thing to install all over the United States.

Mr. KILGORE. Off the end of a runway?

Mr. MORROW. That is right—off the end of a runway. The antenna transmits a vertically polarized signal and the accuracy of the azimuth readings, not the distance portions of TACAN, is dependent upon the antenna being exactly vertical. If it is displaced 1°, the error in the reading of the aircraft will be 1°. If it is displaced 5°, it will give a 5° error. I think that you can see the impracticability of running a 100-foot antenna up on the ground and putting guy wires on it. With any kind of wind or temperature variations it would be difficult to maintain it exactly erect. You can see the difficulties involved in putting it on ships and carriers.

Mr. KILGORE. Is that gyroscopical?

Mr. MORROW. If there were gyroscopic stabilization on board a carrier, I would say they would have a complex situation.

We have never been opposed to the development of any navigational device, and we are not now opposed to any development of navigational devices; but we are opposed to having it arbitrarily imposed

upon us, and particularly when it is not demonstrated to possess the reliability or accuracies that we require. It does not meet the operational requirements; so that where we get into this controversy at the moment is, that TACAN uses the same frequencies as the DME system does; and they are incompatible; and we have now gotten to a point where, if the military is to proceed with their program, they have got to have the 960 to 1,215 megacycle frequency band for TACAN usage.

Mr. HOLIFIELD. Which means the elimination of VOR–DME?

Mr. MORROW. That is right—and the adoption of TACAN as our common system. In other words, all users would have to use TACAN.

Mr. HOLIFIELD. Can you at this point give us an estimate of the amount of money that is already invested in the existing VOR system, and by whom?

Mr. MORROW. The total investment by all—the Government—that is the Federal airways facilities—and all the civil users of aircraft, and the military—who bought 28,000 sets—is $117 million, approximately.

Mr. HOLIFIELD. All right. Do you know what proportion of that is invested by your civil airlines?

Mr. MORROW. I do not know the portion invested by the civil airlines. It is relatively small.

Mr. BALWAN. How about any other civilian aspects of aviation?

Mr. HOLIFIELD. In Federal areas?

Mr. MORROW. I do not quite understand.

Mr. BALWAN. I think the question that the Chairman directed to you was as to the commercial airlines; but in talking with you we learn that there are other people who fly planes besides commercial airlines and the Department of Defense.

Mr. MORROW. I think the Department of Commerce could better answer your question. The total number of aircraft owned and operated by the airlines is less than 1,500 out of 93,000 civil airplanes in the United States. As a matter of fact, the business concerns, alone, own and operate about 22,000 airplanes, of which over 2,000 use multiengine airplanes; so you see that the numbers of planes and equipment involved by the airlines is relatively small.

Mr. RIEHLMAN. Mr. Chairman, could I ask a question?

Mr. HOLIFIELD. Yes.

Mr. RIEHLMAN. Was I correct in understanding you to say that there were only 1,500 planes operated by the commercial airlines?

Mr. MORROW. Yes, sir.

Mr. RIEHLMAN. Do they have any more off the airlines?

Mr. MORROW. Less than 500. That includes international operations. In the domestic operations, they have less than 1,200. The general impression seems to be that all of the flying in the United States is done by the airlines and the military; but that is not so.

Mr. RIEHLMAN. Well, this is somewhat enlightening to me.

Mr. HOLIFIELD. It is to me also.

Mr. RIEHLMAN. I always thought they had a larger number of planes in commercial use than that number.

Mr. MORROW. I may say that the business concerns, alone, according to CAA statistics for 1953, flew 600,000 hours more than the combined total of all the airlines; and it is estimated for 1954 that we will exceed the airlines by a million hours, and by 1960 we expect to fly

5 times as much as they do; so that the operators of business aircraft have a very vital stake in this.

Furthermore, to point out one further thought. We do a different kind of flying from that done by the airlines. We don't fly the airways all the time. We fly across the airways, and in a pattern that the airlines could never meet. I mean they could never meet the requirement. We fly to small communities. For example, there are 6,400 airports in the United States, and there are less than 500 of them that are served by the common carriers. In some cases they have only one flight a day and they get listed, then, as having airline service. Well, if you will just visualize the flight into 500 airports, and then the flights out—not only of those 500, but another 5,900 that are not served by the airlines, the utilization of our aircraft is infinite by comparison, because we can go from where we are to where we want to be, by a direct route, on the routes that we can set up. That is the reason there has been this tremendous growth of what we call "business flying."

Mr. LIPSCOMB. Who puts in the main installations for DME?

Mr. MORROW. The Civil Aeronautics Administration operates the Federal Airways System, and they implement and install the equipment, and make it operate.

Mr. LIPSCOMB. Can the present installations handle TACAN?

Mr. MORROW. No.

Mr. LIPSCOMB. And does the $117 million—that was the figure, wasn't it—include the installation cost of the ground equipment?

Mr. MORROW. Yes.

Mr. LIPSCOMB. So that portion of the equipment will become obsolete.

Mr. MORROW. That is right.

Mr. LIPSCOMB. It will become unuseful?

Mr. MORROW. That is correct.

Mr. LIPSCOMB. Can the TACAN systems be established at the same ground locations as VOR?

Mr. MORROW. No.

Mr. LIPSCOMB. So the whole installation will be out?

Mr. MORROW. That is right.

Mr. BALWAN. How extensive is our installation in respect to VOR-DME?

Mr. MORROW. It is complete. We have 400—I think it is 450—VOR stations in operation, and we have installed about 450 DME's, due to the budgetary limitations, which last year allowed sufficient funds to operate 231 of them; and this chart shows only the distance coverage with the 231 stations. There are a few, I suppose, that will be built in this coming year, with the implementation or initial operation of the DME stations.

Also, not shown on this map, are certain DME stations that would be located on instrument-landing systems at airports. At the present time, we only have about 4 or 5 airports equipped with DME distance information—landing information on the system. I may just explain why that is so very important. At the persent time, we merely have "fixer" space, in connection with the radio marker beacons, but with them it is like driving on a highway—you have no idea where you are until you get to a crossroad intersection, and then you have no more information until you come to the crossroad intersection.

With the present-day operation of aircraft, it is essential that the pilot have exact distance information, particularly when he is making an approach down to a narrow strip of concrete; he has to maneuver that airplane so that he has to come exactly in line with that runway; he needs to know exactly how far he is from the end of the runway, too; and one of the deficiencies of the present system is that when you get a headwind, or wind effects on the landing, he has to estimate where he is; and sometimes his estimate is wrong, and the distance information will very definitely step up the safety of our present aircraft operations.

Mr. BALWAN. Who operates all these stations?

Mr. MORROW. The CAA, Federal Airways System.

Mr. BALWAN. And how many are installed and operating?

Mr. MORROW. Two hundred and thirty-one are shown—450 are installed. The balance are not operating because of the lack of funds in last year's budget.

Mr. BALWAN. And so far as you know, only the business aircraft used this?

Mr. MORROW. Yes. At the present time, the airlines have not purchased DME, TACAN, is the thing. They have not been given any information. Nor have we—when I say we, I mean the business aircraft transport, because it has been so highly classified—however, they have been told that, "Well, now, there is another system, and we may have to use it." And not only do business aircraft operate DME, in the face of that, but so do the airlines; and I think rightly so. We are now being told that the Air Force and the Navy are down to the point where they have got to adopt TACAN.

Mr. RIEHLMAN. Could I ask the gentleman a question?

Mr. HOLIFIELD. Yes. Proceed.

Mr. RIEHLMAN. Mr. Morrow, do you know, or have you been given the information as to the additional advantages that there would be in TACAN?

Mr. MORROW. Yes. I was a member of the Air Navigation Development Advisory Committee, No. 1, which has been called the VORTAC, in which we were given all the technical views and all of the features and characteristics of TACAN.

Mr. RIEHLMAN. Well, then, of course, it is not completely a hodgepodge proposition, is it?

Mr. MORROW. Well, only those who have been cleared for their security are the ones who have it.

Mr. RIEHLMAN. But you have had a complete briefing, so that you know exactly what is to be expected of this new piece of equipment?

Mr. MORROW. They had made many claims for it, of course. Up until the time that we actually bought the equipment to function with, we assumed the claims were valid as to its accuracy and its performance. It was supposed to be just the ultimate in equipment. We found it to be diametrically opposite to that.

Mr. RIEHLMAN. Well, that is the point that I am trying to develop. Now, you have had experience with it.

Mr. MORROW. Yes. I have seen it, and I have a briefcase full of technical analyses on TACAN and VOR.

There is one other point I would like to lead up to, in the light of your question. Before a valuation of TACAN versus VOR–DME

could be made, it was necessary to establish in writing the operational requirements of these short-distance navigational aids. That had to be redone, and approximately a year ago—well, it was a little over a year ago—the Air Traffic Control and Navigation Branch of the Coordinating Committee was convened, and it drew up a statement of operational requirements of the short-distance navigation aids of the common system.

That was participated in by the Air Force and the Navy, as well as by Mr. Karant and myself, the CAA, and the Air Transport Association, representing the airlines. The VORTAC Committee then analyzed VOR–DME and TACAN, in the light of meeting these requirements and the conclusions that had been reached that neither one of those systems met those requirements; and the conclusions of that Committee are that neither one of those systems meets those requirements, but that VOR–DME does meet those requirements, except for certain specific tactical requirements which were outlined by the military.

However, since TACAN doesn't meet these military specifications, we don't understand how the military can buy it; and it doesn't even meet their own specifications—certainly not ours; and our specifications are much more liberal. For example, you cannot fly an airplane that accurately, and the faster it goes—if you can visualize trying to maintain 1° of accuracy in navigation, flying 700 or 800 miles an hour, it is physically impossible to do it. It just could not be done.

(Discussion off the record.)

Mr. MORROW. What we maintain is that the maneuvering of the aircraft at those speeds covers so much distance that there is a channel—the path of the aircraft is actually going to be wider than this 1°. You cannot hold it that close. If you did, you would tear the airplane apart. However, it is none of our business, or, it is not within our prerogatives to tell the military what their operational requirements are. But the TACAN, you know, does not meet even the military requirements.

Mr. HOLIFIELD. How nearly does it come to meeting it?

Mr. MORROW. Well, it comes a long way.

Mr. BALWAN. How do you know—if I may interrupt—

Mr. HOLIFIELD. Yes.

Mr. BALWAN. Do you have any information which enables you to make that decision, that TACAN doesn't meet that?

Mr. MORROW. Yes; it was in the VORTAC Committee report.

Mr. BALWAN. Do you have a copy of that report here?

Mr. MORROW. Yes, I do.

Mr. BALWAN. And were you a member of the VORTAC Committee?

Mr. MORROW. I was.

Mr. BALWAN. Was Mr. Karant?

Mr. MORROW. Yes. I might point out that the consultants—by the way, the VORTAC Committee was provided with three consultants, who are very high-level, well-known, well-established, competent authorities in the field of electronics and in this particular field—and I might mention that they were Dr. Wiesner, of the Massachusetts Institute of Technology; Mr. R. C. Newhouse, Bell Laboratories; and Dr. H. R. Skifter, Airborne Instrument Laboratories.

Mr. BALWAN. Does that firm have any contracts at all with either VOR or TACAN?

Mr. MORROW. They have certain subcontracts and certain work that they are doing for Federal Telephone Communications. I only know that they have some work, but I don't know the detail of it.

Mr. BALWAN. This consultative committee represented whom?

Mr. MORROW. The VORTAC Committee.

Mr. BALWAN. Do you have the report of that?

Mr. MORROW. Yes.

Mr. BALWAN. Mr. Chairman, let me ask for the reports of the consultative views of the VORTAC Committee.

Mr. MORROW. I might say the report is a classified document yet. It is still classified.

I have a declassified version here from the consultants' report, and I am just wondering what the security status of that might be.

Mr. HOLIFIELD. Let me ask this question. Who has charge of the full classified report?

Mr. MORROW. The Air Navigation and Development Board.

Mr. HOLIFIELD. I suggest that they would be the ones we should ask for it, and that we ask that it be declassified.

Mr. MORROW. I can give you the declassified version, and some of these things that I have just been mentioning, here, in this report.

Mr. HOLIFIELD. I might say that this subcommittee is cleared for classified information, and we have never been denied, on a basis of our need and the unpublished work of the subcommittee, classified materials; so we won't put you in an embarrassing position.

Mr. MORROW. That is what I mean. I happen to know that the military knows about your Committee's interest in it, and that they are going to hit very hard toward anyone making any disclosure of security information on it. There is a statement——

Mr. HOLIFIELD. Without objection, this declassified version will be accepted for the committee files, and we will, later, in executive session, talk about the others.

Mr. RIEHLMAN. This doesn't put Mr. Morrow in any embarrassing position, to furnish us this information, because it is declassified.

Mr. MORROW. This is public information. We published 1,400 copies of it, so——

Mr. RIEHLMAN. Yes.

Mr. MORROW. There is a statement out in the consultants' report, that neither VOR–DME nor TACAN meet the statutory requirements. These are both the classified and declassified versions. I might say, then, that before the consultants could conduct their tests, they had to spend a sizable amount of money modifying the sets, themselves, to make them work, to the extent that they could even test their potential accuracies and their potential performance; and, to me, that was an astounding thing, that after several years of extensive and very expensive development, a device should be so fully developed that, when the consultants were given these sets, they started to examine them and test them, and they came back and told the committee that they were astounded at the lack of performance, in the light of what they had been told about TACAN; and they asked the committee for authorization to spend a very sizable amount of money.

Mr. HOLIFIELD. Do you know approximately how much?

Mr. MORROW. I know that the consultants, themselves, were given $25,000. In addition to that, the Federal Telecommunications Lab-

oratory, with the Navy paying the bill, spent considerably more money in actually making the modifications with respect to these few sets that they tested.

Mr. BALWAN. Was there a production contract concurrently with this evaluation that was going on?

Mr. MORROW. Yes. We had been told, long before the VORTAC Committee was established, that you might as well plan on getting TACAN, because production units are rolling off the line. Well, that is a nebulous term; but after we got into the committee deliberations, we were given, from time to time, rates of production of the various contractors, by the Navy representatives, so that the units are actually in production, and have been, for some time.

Mr. RIEHLMAN. Mr. Chairman, could I ask another question?

Mr. HOLIFIELD. Yes.

Mr. RIEHLMAN. Did I understand you correctly, there, to say that the Air Force or Navy had 28,000 sets?

Mr. MORROW. Well, they have 28,000 or more VOR sets.

Mr. RIEHLMAN. Are they using them?

Mr. MORROW. No.

Mr. HOLIFIELD. Have they ever used them?

Mr. MORROW. They are using several thousand of them. Most of the 28,000—I cannot tell you the exact number that are actually installed in aircraft, but the majority are not installed in aircraft; they are in warehouses.

Mr. RIEHLMAN. Do you know where they are in warehouses?

Mr. MORROW. Well, I know where some are.

Mr. BALWAN. How many, and where?

Mr. MORROW. Well, there are in excess of 6,000 sets in a warehouse at Dallas, Tex.

Mr. HOLIFIELD. Could you tell us approximately how much each one of those sets cost?

Mr. MORROW. I would estimate that they cost about $3,000 to $4,000 each.

Mr. BALWAN. You say that those are VOR sets?

Mr. RIEHLMAN. Mr. Chairman, this is interesting testimony.

Do you have any information as to the reason for their procuring them and then not using them?

Mr. MORROW. I only have an opinion. It appears to me the people on topside have been planning on using TACAN.

Mr. BALWAN. And for that reason they did not want to put these into use?

Mr. MORROW. That is right; and I think, if TACAN were going to be used extensively by the military, I would probably follow the same plan, because the functions of the two systems are identical. That is, the pilot looking at an indicator, couldn't tell whether it was coming through TACAN or whether it was coming from VOR–DME.

Mrs. GRIFFITHS. Are you suggesting that when they made the agreement, they meant, right then, not to keep it?

Mr. MORROW. They must not have intended to keep it, because the people who were developing TACAN have known since the day they started on it that it was incompatible with the correct and established system. There was no mystery about it.

Mr. RIEHLMAN. Is there a possibility that there were two different factions working in the department, with two different views as to what piece of equipment they might use?

Mr. MORROW. I don't know.

(Discussion off the record.)

Mr. MORROW. I would like to make a satement for the record. It would appear to me, just from looking at it as an outsider, that the Navy representatives of the various coordinating committees of which they were members, either were not aware of TACAN developments, or they were hypocritical in agreeing to this system, and knowing all the time—if they did know—that it was incompatible with TACAN.

Mr. RIEHLMAN. Well, if they knew something about it, they certainly were irresponsible officials.

Mr. MORROW. One of the things that we agreed on, that was alluded to, now, is the fact that, if this irresponsibility took place, we are supposed to suffer financially, and we think, safetywise, because of this irresponsibility.

Mr. LIPSCOMB. When do you anticipate that you are going to be asked to start using TACAN?

Mr. MORROW. TACAN cannot possibly be available as an implemented system for at least 10 years.

Mr. LIPSCOMB. What is the problem today, then?

Mr. MORROW. The problem today is that the Military and Air Navigation Development Board have recommended that the DME's be shut off, decommissioned on June 30.

Mr. LIPSCOMB. Then what will be put in use, between June 30 and the next 9½ years?

Mr. MORROW. That is another thing that we are complaining strenuously about, that there is no orderly phasing-in and phasing-out one system.

Mr. LIPSCOMB. What danger is that to the safety of aircraft communication and transportation?

Mr. MORROW. Well, it eliminates one part of the system. In other words, it eliminates the distance portion of the rho-theta system. That is a distance-and-azimith system. It means that, with the common system, which we have all agreed and which we have been implementing toward, one leg of the chair will be left off.

Mr. LIPSCOMB. That is very important?

Mr. MORROW. Very important.

Mrs. GRIFFITHS. What is their purpose?

Mr. MORROW. Because, in order to proceed any further with TACAN, they must have the DME frequencies. And I might say one other thing. It is considered that the radio spectrum is a natural resource of the country, and in all of our Committee studies and so forth, an attempt is made to conserve this natural resource or to conserve the radio spectrum. In other words, we try to use as little of it as possible, so that everybody—television, radar, and everything—will have a place to operate.

In the case of the Federal Communications Commission, it has set aside 250 megacycles of spectrum for use in air communication. The DME, as we now have it established, uses only 50 of these 250 megacycles. TACAN uses the entire 250. In other words, TACAN is wasteful of the radio spectrum in that it uses five times as much, and

this goes back to the original argument, way back in 1939, in special committee 40, in which we were trying to conserve the spectrum, and the system that we adopted made it possible to do the job with 50 channels instead of 250.

Mr. LIPSCOMB. Mr. Chairman, if DME continues to operate, can they still do the proper development work on TACAN?

Mr. MORROW. Yes.

Mr. LIPSCOMB. Even though DME continued to use the frequency that TACAN needs?

Mr. MORROW. They can do the development work, but you cannot do the fully implemented TACAN stuff.

Mr. LIPSCOMB. But I mean, when you talk about phasing-in, they should have it properly developed and in production, before they phase it in; but they are not saying that DME should go out, because they cannot properly develop the TACAN until they get the frequency?

Mr. MORROW. No, that is not quite it.

Mr. LIPSCOMB. I mean, that is not the case.

Mr. MORROW. No. As I understand——

Mr. LIPSCOMB. What I am trying to arrive at is, the reason they are saying DME must be abandoned, is because they need the frequency to develop TACAN.

Mr. MORROW. They don't need it to develop TACAN, but——

Mr. LIPSCOMB. To make it operational, then?

Mr. MORROW. In order to implement the system. In other words, to start installing TACAN ground stations around the country, they have got to shut DME down. Now, when you say "develop the system," it means, to me, the laboratory work.

Mr. LIPSCOMB. Yes.

Mr. MORROW. But to implement and operate the system, as soon as you start duplicating these stations around with TACAN stations, then you get interference between the frequencies, and neither one, I think, will work.

Mr. LIPSCOMB. Well, if they get someone to find out if it is operational——

Mr. MORROW. Well, they have been operating experimental stations.

Mr. LIPSCOMB. That is what I mean.

Mr. MORROW. And it is possible to operate a few TACAN and DME stations. It is just a matter of stepping up the frequency, the channels being so operated that there is no interference.

Mr. LIPSCOMB. Then there is really no reason to do away with DME, just to make TACAN operational?

Mr. HOLIFIELD. In the development phase, you mean?

Mr. MORROW. Yes. But there is no way to phase-up one, and phase the other down, so that, as of a certain day, you can go from DME to TACAN.

Mr. LIPSCOMB. There has been no consideration given to phasing this thing up some day, when it is developed and operating, so it could be properly phased in, in your estimation?

Mr. MORROW. No, I don't see how it could be phased in, due to the fact that it would mean that you would—let us say you are operating an airplane that is equipped with VOR–DME, it means that we would have to install the TACAN unit in the airplane and have it ready for

"D-day", and, on that particular day, I turn off my one set and turn on the other set, and we suddenly go from one kind of operation to the other. I say that is a practical impossibility—No. 1, because we would have to take one set out and actually put the other set in, which means the two systems would be operating together for some time.

A similar situation exists right now in phasing-out the low-frequency ranges which we have been using for so many years. We have been phasing them out since 1948, and we are still operating them. The low-frequency ranges are still in use, and, I think, will continue to be in use, because you cannot change from one system to the other system——

Mr. LIPSCOMB. But you have different frequencies?

Mr. MORROW. That is right.

Mr. LIPSCOMB. In this case you have the same frequency?

Mr. MORROW. The thing we fail to understand is why, from the very outset, the Navy would proceed with the development in a frequency band that was allocated and was in conflict, when there was actually available another frequency band that could have been used, which does not interfere with our system.

Mr. HOLIFIELD. Now, that is important in my opinion. You say that there was another band in which they could have operated?

Mr. MORROW. Yes. As a matter of fact, the rho-theta question, and the NBAA position recommended the development, now, of this Army range unit, which would duplicate TACAN's performance in this particular spectrum, and in view of the fact that there is a minimum of at least 3 more years of development work on TACAN before it will be—in their own statements—developed. We say that within that 3 years we can develop this completely new system, which will meet the common system requirements, including the military's, and will meet the civil requirements—it can be phased in orderly and without causing any hardship or interference or upsetting anyone.

Mr. HOLIFIELD. Do I understand you to mean that there is a third system?

Mr. MORROW. It is not in existence. It has been put on paper in the same manner that TACAN was, away back in the early days. It has been investigated by the consultants, the technicians, and it is possible. As a matter of fact, it would be much easier to develop that system today than would have been the case 10 years ago or 5 years ago, because of the know-how, and the—well, the progress in the state of the art. We know a lot more about electronics, and this particular type of electronics, in that frequency range, today, so that all of the technical people with whom I have talked say that it would be a snap to develop what is generally referred to as a 1,000-megacycle Army system today; and it could then be used in conjunction with our present DME, both by the military and civil, without any of the interference, and without destroying the investment that the taxpayers have already made in the existing rho-theta system.

Hr. HOLIFIELD. Now, would this new system meet the requirements of the military?

Mr. MORROW. It would meet the operating specifications that they have established.

Mr. LIPSCOMB. Is the TACAN instrument easier to maintain than the DME? Is that the reason—one reason——

Mr. MORROW. It is extremely complicated, and it is just the other way around. TACAN circuitry is extremely complicated; and, by the way, due to the complexity and the unreliability of the TACAN units, they must operate, attended 24 hours a day by a technician, and not just an ordinary man, an ordinary workman. He must be an electronic technician to make the adjustments. Merely to duplicate the several installations, alone, around the country, would require approximately 3,900 technicians, compared with the VOR–DME system, which operates completely unattended, with no one there. We have VOR stations located out on mountains, in the desert, and in places of that kind, which have no attendants at all, and we question that as a matter of practical operating requirement. I do not think the Congress would want to appropriate that much money, alone, just for operating—particularly CAA, which has a tough time with its budget, now.

Mrs. GRIFFITHS (presiding). How much training would be required?

Mr. MORROW. I don't believe I can answer that too accurately, except to say that the operators would have to be very well trained and well-qualified. This is not a simple thing. The best thing I can say is that it is far more complicated than television, and the caliber of the technician would have to be better than that of the one whom we call an expert television serviceman; and I notice that the military now is using all kinds of inducements, trying to get electronic technicians, and it is claiming that that is one of their big shortages, is in the number of technicians available to do this sort of work.

Mr. LIPSCOMB. Can the research and development work that has already been performed on TACAN be switched over into this other frequency or this other instrument about which you have been talking, that was working on another frequency?

Mr. MORROW. Electronic technicians and the development know-how obviously can be used on this and on other devices, for that matter. In other words, in building this thing, somebody has learned a lot about the technique, so that the state of the art has been advanced, and the research work and techniques that have been developed obviously would apply to the other system. That is why the development of the new system would be relatively simple as compared to having started the same thing 10 years ago, or even 5 years ago.

Mr. LIPSCOMB. Do you know whether any of the techniques that have been developed through TACAN have been incorporated into the VOR–DME?

Mr. MORROW. As a matter of fact, I would put it the other way round. Many of the techniques that we originally developed in VOR-DME were incorporated in TACAN, because TACAN came later.

Mr. LIPSCOMB. But there have been improvements in VOR–DME, haven't there?

Mr. MORROW. Oh, very definitely.

Mr. LIPSCOMB. And have those improvements come as a result of the research and development work in TACAN?

Mr. MORROW. No. The people who have been working on VOR–DME have had no access to the TACAN development.

Mr. LIPSCOMB. For instance, you said that Collins was working on the research and development of TACAN. Is that right?

Mr. MORROW. Yes.

Mr. LIPSCOMB. Is Collins doing any work on the VOR–DME?

Mr. MORROW. They are doing no work on the VOR–DME. They, of course, manufacture and sell VOR equipment. So far as I know, there is nothing in TACAN that has been any improvement to the Collins VOR.

Mr. LIPSCOMB. No techniques in TACAN have been incorporated in the VOR?

Mr. MORROW. No. The only thing that I was talking about was just a general improvement in electronic know-how; but I don't think there has been any direct circuitry, or practices that were used or that were developed in TACAN, that have been incorporated in any other equipment. But what I meant was that they may have found some characteristics to aid high frequencies that are generally applicable to the electronics industry as a whole.

Mr. LIPSCOMB. Well, then, it was due to the report of what Collins found out about VOR, that it came to be incorporated—that those techniques—in TACAN research?

Mr. MORROW. As a matter of fact, I believe the reason Collins was given this contract was because of the know-how that they had developed—that other engineers had developed over the years in working with VOR. As a matter of fact, they are generally accepted to be "tops" in that particular field; and what Collins has been working on in this development contract is similar, or it is to do the same thing that the consultants had to do before they could test the set. It is essentially to try to make the set work.

Mr. LIPSCOMB. Do you think that the costs of the research and development work on TACAN are less because Collins did that, and had previously learned all the techniques?

Mr. MORROW. No, because that was on top of the development work that Federal had done; so it could not be any less. It is bound to be on top of whatever money was spent with Federal telecommunications.

Mr. BALWAN. What is our investment to date on TACAN, in money either spent or obligated? Do you have any idea as to the amount?

Mr. MORROW. In excess of $300 million.

Mr. RIEHLMAN. Madam Chairman, may I get this question correct? This $300 million has already been spent or——

Mr. MORROW. Obligated.

Mr. RIEHLMAN. Or obligated? Well, that is the question—obligated for the production of a number of these sets; which, of course, has not been completed; and do you have any idea when it will be completed?

Mr. MORROW. Well, the only statement I have is by the consultants, and in their report, in which they state that it will take a minimum of 3 years additional engineering development work.

Mr. BALWAN. Reengineering, or on engineering?

Mr. MORROW. Well, it is reengineering and development, to prepare the production specifications. That is the word they used.

Mr. RIEHLMAN. Of course, they are not in mass production?

Mr. MORROW. But they are.

Mr. RIEHLMAN. Do you have any idea how many sets have been produced?

Mr. MORROW. Well, as of last August, they listed 400 sets as having been delivered.

Mr. RIEHLMAN. Out of how many?

Mr. MORROW. I don't know, except that they were supposed—the production rate was supposed to be several hundred sets per month, with three contractors. Now, they were trying to step up their production. I don't know that that has been attained though. So far as not being in production is concerned, it is in production. It may look like production, now, awaiting engineering changes. I would certainly hope so. I don't know that.

Mr. RIEHLMAN. We will be able to get that from the military people.

Mr. MORROW. They are going to say the things you are asking here, which is information that I certainly cannot give you.

Mr. RIEHLMAN. Well, the military service should have it.

Mr. LIPSCOMB. Do you have any figures on the reliability and accuracy of TACAN, in terms of military requirements, as to distance or range?

Mr. MORROW. The military practice and specifications call for an accuracy of $\pm 1°$, and a special coverage of 200 nautical miles. The $\pm 1°$ is obtained out to approximately 100 miles, but at about 125 to 130 miles it fades out completely; and beyond 100 miles, the accuracy is due to an attenuation of the signal; in other words, a weakening of a signal. As the signal gets weaker, the accuracy error goes up to far in excess of anything VOR does; and, as a matter of fact——

(Discussion off the record.)

Mr. LIPSCOMB. May I follow this? Are these studies you are giving us the figures on the reliability now of some sets that are in production?

Mr. MORROW. They were supposed to be production sets.

Mr. LIPSCOMB. Production sets?

Mrs. GRIFFITHS. Have you any other questions you desire to ask?

Mr. RIEHLMAN. I had one, Madam Chairman.

Something again has been brought into the picture. We were not too well briefed on this morning's discussion here; but I was not aware, until your testimony, Mr. Morrow, that there was a third piece of equipment being considered. Have you discussed that with the military people, and do you have any information as to their view toward this piece of equipment, which is, as I understand it, only in the design stage, or has been on the trestleboard for consideration?

Mr. MORROW. I don't know. I have had no contact with anyone of the military, to hear what their reaction was.

Mr. RIEHLMAN. Well, are they familiar with it?

Mr. MORROW. Yes.

Mr. RIEHLMAN. And they know exactly—would it be NBAA that is interested in this new piece of equipment?

Mr. MORROW. Well, yes—we would.

Mr. RIEHLMAN. And you have kept the military people apprized with your ideas and thinking in the development of this piece of equipment?

Mr. MORROW. Well, this all came out in the VORTAC Committee.

Mr. RIEHLMAN. I see.

Mr. MORROW. And the military representatives were part of the committee; and I might say that there was a second ad hoc committee, established by the Air Navigation Development Board, in which the Air Force and Navy representatives participated, in which this third

alternate system was thoroughly investigated, and that ad hoc committee reported it to the Air Navigation Development Board; but they merely reported it as a possibility, and so forth.

Mr. RIEHLMAN. You had no information as to their attitude toward it and toward the report?

Mr. MORROW. Yes, there is a letter here, which has been declassified, too, in which it says that, on January 28, the ad hoc group made its recommendation to ANDB. While the alternative recommendation had many attractive features and held the promise as the ultimate civil-military system, the extra cost in time and dollars was very high. The military indicated they were unable to afford the extra time to develop the alternate recommendation for tactical use.

Mr. RIEHLMAN. Now, let us get on the record again, clearly: The information that you gave—I think, to my colleague, Mr. Lipscomb—was that it was as a matter of fact 3 years before this piece of equipment that you are interested in could be put into production and use. Is that your opinion?

Mr. MORROW. The 3-year figure was on TACAN, and my statement was that, since at least 3 years are required for engineering and development of TACAN, we should devote those 3 years to the development of the new stuff, and then I felt—and I think there is a pretty general agreement among many electronics people—that they can develop this system in 3 years; also, the statements here of the time and the extra cost in money and dollars, was strictly the Air Force's statement, without any qualifications. They didn't substantiate the figure and they cannot substantiate it, either.

Mr. RIEHLMAN. Well, now, you did say, though, a few minutes ago, that it would be 10 years before TACAN could be actually put into implemented operation?

Mr. MORROW. In the common system—correct.

Mr. RIEHLMAN. Yes, in the common system.

I guess that is all, Madam Chairman.

TESTIMONY OF MAX KARANT, REPRESENTING THE AIRCRAFT OWNERS AND PILOTS ASSOCIATION

Mrs. GRIFFITHS (presiding). Will you give your name to the reporter, Mr. Karant?

Mr. KARANT. Max Karant.

Mrs. GRIFFITHS. And your address?

Mr. KARANT. Street, post office, or business address?

Mrs. GRIFFITH. Street.

Mr. KARANT. 4644 East-West Highway, Bethesda.

Mrs. GRIFFITHS. And whom are you representing?

Mr. KARANT. I represent the Aircraft Owners and Pilots Association.

Mrs. GRIFFITHS. Will you raise your right hand, please?

(The witness was thereupon sworn.)

Mr. KARANT. In view of the time, Madam Chairman, will you please tell me when to stop?

Mrs. GRIFFITHS. Yes, you may proceed.

Mr. KARANT. Our organization is patterned very closely after the American Automobile Association. We represent the individual aircraft owner and pilot.

In order to be a member of our organization, he must either be a certified pilot or an aircraft owner. About 70 percent of our members are aircraft owners. Our total membership now is on the order of 42,000.

We are concerned with this common system. We were a party to the common system. We were members of that SC–31 that has been referred to, and we fought for the common system, along with the airlines, the military, and everyone who was concerned. We did this because we know that ultimately we must have the equivalent of a highway system in the air, if aviation is to get out of the highly complex professional type of operation and into the man-of-the-street type of thing—as the automobile has. The rho-theta system you have referred to—that Greek-named system, is explained in this way. It is shown on the last page of this. What it does is actually to establish, for the first time, the highway in the sky that we speak of. It gives the man a track to fly on—and it gives him a milepost upstairs, as he goes along, just as you would have on the highway.

This is a complicated business, technically, as you probably gathered from listening to the testimony up to this time. In reality, however, it is the essence of simplicity for the man who flies his own plane, or who is in the military, an airplane pilot, and the airline pilots, because he sets the dial. It tells him what to do.

We favor this very much. Our common denominator has been on the level of the average person. Invariably these days, because of the cost of flying and the cost of airplanes, the average, ordinary person is the businessman. Many of Mr. Morrow's corporation's pilots, for example, are members of ours.

In fact, businessmen and a considerable number of professional men fly their own aircraft these days, as well as doctors, attorneys, and construction people, and so on. As a matter of fact, I believe you have some pilots on this committee.

Mr. RIEHLMAN. Mr. Kilgore talked as though he was a pilot.

Mr. KARANT. He is a member of our association.

I was interested to hear a reference to the fact that the airlines have 1,200 airplanes. In our case, we actually represent something on the order of 98 percent of all the civilian aircraft operating in the United States. If the airlines have 1,200 airplanes, if we subtract that from the total registered by the Federal Government you come up with 93,395 airplanes that are not owned and operated by the airlines; but they are still civilian aircraft being flown by civilian pilots.

So, you see we have the makings of a small automobile industry; and that is why we guard this thing as jealously as we have indicated.

At the present time there are something over 300,000 civilian pilots. Another thing in which you might be interested, so far as the scope of this business is concerned, is that most people think of the airports in terms of passengers, and the control tower, and all these things. Most people do not know that there are exactly 170 commercial airports, out of 6,400 airports in the United States.

The CAA will tell you that the only measurements they have made involve the 170 airports. They have no measurements whatever as to what is taking place on the other airports.

We know that civilian aviation flies more miles and uses more gasoline; there are more people, there is more of everything in general civilian aviation than there is in scheduled airlines.

Mrs. GRIFFITHS. What would be the effect of this?

Mr. KARANT. This jeopardizes the common system. This jeopardizes our highway of the sky. Now, what happens here is, we suddenly find ourselves faced with having educated our members, our people out around the country, in using this new system. We educated them so well that everybody bought, once the common system was adopted. A very substantial number of people bought this equipment out of their own pocket. Certain systems, even today, are used only by nonairline civilian aircraft.

Mrs. GRIFFITHS (presiding). We would like to remind you that this is an executive session, and that those things you have said here will be kept confidential, and that you should keep them confidential.

(Discussion off the record.)

(Mr. Karant, on behalf of the Aircraft Owners and Pilots Association, submitted a supplement terminology reference, which is as follows:)

SUPPLEMENT TERMINOLOGY REFERENCE

Ever since the controversy between VOR–DME and TACAN broke out into the open, AOPA has been repeatedly questioned by Congress, the press, and its members about the bewildering confusion of initials and abbreviations involved. Here is what the more commonly used mean:

ANDB: Air Navigation Development Board, a Government body concerned with the development of devices and systems to be used for air navigation. Voting is generally confined to the heads of two agencies—Defense and Commerce.

RTCA: Radio Technical Commission for Aeronautics. A nonprofit cooperative association supported by both Government and industry organizations concerned with aviation operational and communications maters. This is the organization that was responsible for the development of the common system of radio and navigational aids on the airways today, for which it was awarded the famed Collier Trophy in 1948 for "the greatest achievement in aviation in America."

SC–31: Special committee No. 31, the specific group within RTCA that actually devised and wrote the blueprint for the common system, which later was adopted by Congress, and for which RTCA ultimately received the Collier Trophy. Membership on SC–31 included all segments of aviation, including the military.

ACC: Air Coordinating Committee. This is a forum somewhat like RTCA, but in which only Government agencies concerned with aviation clear their policies or proposed actions, so as to avoid conflict between agencies. Industry and users are permitted to participate in ACC activities, but only on a nonvoting basis. Only Government agencies have a vote in ACC; industry and users do not.

AOPA: Aircraft Owners and Pilots Association. Often referred to as "the motor club of the air," it has more than 40,000 members, all of them either pilots, planeowners, or both. AOPA is concerned with the welfare and growth of nonairline civil aviation, which encompasses more than 98 percent of the country's 93,395 registered civil aircraft, nearly 300,035 civil pilots, more than 6,000 civil airports, a number of manufacturers—altogether a good-sized young American industry.

NBAA: National Business Aircraft Association, an organization concerned almost entirely with the problems of corporations owning and operating their own aircraft. Its active membership is 297 corporations.

ATA: Air Transport Association, representing the 42 scheduled airlines.

CAA: Civil Aeronautics Administration, the operational and policing Government agency concerned with civil aviation. Under Department of Commerce.

CAB: Civil Aeronautics Board, an independent agency that makes rules and regulatory decisions affecting civil aviation. The CAB writes the regulations, the CAA enforces and administers them.

VHF: Very high frequency, a segment of the total radio frequency allocation. The radio frequency bands are designated in this manner:

VLF: Very low frequencies—below 30 kc.

LF: Low frequencies—30–300 kc.

MF: Medium frequencies—300–3,000 kc.

HF: High frequencies—3,000–30,000 kc.
VHF: Very high frequencies—30–300 mc.
UHF: Ultra high frequencies—300–3,000 mc.
SHF: Super high frequencies—3,000–30,000 mc.
EHF: Extremely high frequencies—30,000–300,000 mc.

VOR: VHF omnirange. This is the basic system now in widespread use throughout the United States, and has largely replaced the now obsolete low-frequency radio ranges. Unlike the low-frequency ranges, which only gave a pilot 4 specific courses he can fly on each range, the omnis (as they are popularly called) give the pilot 360 courses, 1 for each degree of the compass. Thus omni is infinitely more useful to the pilot.

DME: Distance measuring equipment. This general term applies to any such device which essentially is a combination receiver-transmitter (called an "interrogator") carried in the airplane. This sends a signal to the ground, where it triggers a receiver-transmitter (called a "transponder") which sends a signal back to the airplane. The interrogator measures the time required for this sequence. The result is shown on a cockpit instrument, calibrated in miles. All this happens almost instantaneously, so the pilot actually has a continuous reading showing him the distance his plane is from the ground DME station at any given moment. Both the DME and VOR ground stations are always installed together, so the pilot thus has continuous information concerning his track, and his distance on that track. To the average user, this system thus becomes the first "highway in the sky."

TACAN: Tactical air navigation, the name of a system of radio navigation developed by Federal Telecommunications Co., Nutley, N. J., a division of IT & T. TACAN operates essentially in the same manner as VOR–DME, giving the pilot heading and distance information continuously. However, all of TACAN operates in the 1,000-megacycle band, hence is UHF. It is this fact which brought about the technical conflict between TACAN and VOR–DME, because the civil DME also operates in the 1,000-megacycle band, hence conflicts with what the military are trying to do.

VORTAC: The "VOR" from the VOR–DME system and "TAC" from TACAN were combined to designate the name of the special committee formed by ANDB to study the controversy between the two systems, and recommend a solution. Essentially, VORTAC was a Government committee, although it departed from the normal somewhat in that it gave voting status to the three non-Government organizations participating its deliberations: AOPA, ATA, and NBAA.

Rho-Theta: Technical term that describes the basic functions of a navigational system. The Greek letters are used because they are commonly used by mathematicians and scientists to designate such functions. "Rho" signifies distance, "theta" azimuth or track. So a rho-theta system is one that gives the user both distance and azimuth. Both VOR–DME and TACAN are rho-theta systems.

(Whereupon, at 12:06 p. m., Tuesday, March 1, 1955, the subcommittee adjourned.)

MILITARY PROCUREMENT OF AIR NAVIGATION EQUIPMENT

TUESDAY, MARCH 8, 1955

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON MILITARY OPERATIONS,
OF THE COMMITTEE ON GOVERNMENT OPERATIONS.
Washington, D. C.

The subcommittee met, pursuant to notice, at 10 a. m., in room 1501, New House Office Building, Hon. Chet Holifield presiding.

Present: Representatives Holifield (presiding), Dawson, Garmatz, Fascell, Kilgore, Griffiths, Hoffman, Riehlman, and Lipscomb.

Also present: Michael P. Balwan, staff director; James F. Eckhart, assistant counsel; and Earl J. Morgan, investigator.

Mr. HOLIFIELD. The subcommittee will be in order.

During the 83d Congress this subcommittee under Congressman Riehlman studied, held extensive hearings and issued a report on an Air Force development and procurement of an airborne radio combination transmitter and receiver, technically referred to as the ARC–21. That subcommittee found a situation in which it believed the Air Force had gone into production on an item which was not yet fully developed nor which had become operationally reliable. Admittedly, this was a hindsight view. It was the Air Force's contention that this equipment was desperately needed during the period when the Korean conflict was active. It was not the subcommittee's purpose to tell the Air Force whether this item or that item was a better instrument with which the Air Force should fight a war. The subcommittee was concerned, however, with the possibility that the Air Force had gone into production on an item costing many millions of dollars which, according to certain reports made available to the subcommittee, showed the ARC–21 to be an unsuitable device for use by Tactical Air Command, Military Air Transport Command, and Strategic Air Command.

As a result of those hearings, the Air Force undertook an extensive reevaluation of the suitability of this piece of equipment. Last month this subcommittee informed the Air Force that it intended to follow up the recommendations of the Riehlman subcommittee. Recently this subcommittee was informed that the Air Force had not made its final report.

It has been recently brought to the subcommittee's attention that the military departments might be involved in a similar situation in the development and production of an aerial navigating device known as TACAN. According to the information which the subcommittee has, an impression has been created that there is a parallel developmental history of the ARC–21 and the ARN–21 known as TACAN.

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This subcommittee has been told that the Department of Defense has participated in the development of what is known as a common system for aerial navigation. This participation has been through the Air Navigation Development Board, a coordinating agency made up of a member from the Department of Commerce, and four members from the Department of Defense. Three of these four members, it is my understanding, are seated in this hearing room this morning or at least will be available to us during the hearing. They are: Dr. Donald A. Quarles, Assistant Secretary of Defense (Research and Development); the Honorable Trevor Gardner, Assistant Secretary of the Air Force (Research and Development); and the Honorable James H. Smith, Jr., Assistant Secretary of the Navy (Air and Research and Development).

The Air Navigation Development Board is reported to have developed the criteria and specifications for a common system of air navigation over a period of years from 1947 to the present time. It is our understanding that this Board agreed to and developed a device known known as VOR–DME.

According to the newspapers and other sources of information, the Department of Defense conceived and developed an aerial navigational device known as TACAN in spite of the Department of Defense agreement on VOR–DME as a common system. TACAN is built according to military specifications and is reportedly more accurate and mobile. On the other hand, TACAN is reported to be unreliable and still in an experimental stage.

Recently the Air Navigation Development Board rendered a decision which is reported to make TACAN the acceptable instrument for the common system which would replace VOR–DME. The implications of this decision have a serious significance to this subcommittee if some of the allegations in this controversy have basis in fact.

The purpose of these hearings is to determine whether the Department of Defense, through the Department of the Air Force and the Department of the Navy, is making a wise procurement. This subcommittee is interested to know how the military research and development functioned in the Department of Defense in the making of this decision. This subcommittee will also be interested to know how the requirement for TACAN was determined. The subcommittee notes discussion in the press concerning the connection between TACAN and any possible agreements of the Department of Defense with NATO countries. We hope that this hearing can bring out some information on that phase of our military activity. While the subcommittee does not intend to pass upon the problems of interstate commerce, it does not see how it can understand this problem without reviewing, as a matter of background, the position of civilian aviation interests in this controversy.

At this point it might be well to divert from the prepared statement to say on March 1st we did have an executive hearing in which witnesses appeared and gave the committee certain information.

The subcommittee hopes that the various Department of Defense witnesses who are present this morning will develop the Department of Defense position with respect to the allegations and the understanding of the program as they have been related in this statement.

The subcommittee hopes that most of the testimony can be developed in open and public hearings. It realizes, however, that many

aspects may contain classified information and therefore must be taken in executive session. I hope it is understood, therefore, that witnesses will proceed as far as they can with information that is unclassified. As soon as each witness has completed his statement on information which is unclassified, the subcommittee may elect to proceed in executive session.

One of the problems of holding subcommittee hearings is that they must be scheduled when many other committees are active. Several of this subcommittee's members are also members of committees which are in session at this time. It may be necessary from time to time to call recesses if a substantial number have to leave in order to vote at those meetings.

The subcommittee understands that Dr. Quarles, the Assistant Secretary of Defense for Research and Development, will make the first statement. It is also understood that Dr. Quarles has expressed a suggested order in which witnesses might testify in order to present a complete historical development of this controversy.

At this time the committee will be honored to hear from the Assistant Secretary of Defense, the Honorable Donald A. Quarles.

Mr. Quarles, I believe you have a prepared statement.

STATEMENT OF DONALD A. QUARLES, ASSISTANT SECRETARY OF DEFENSE; ACCOMPANIED BY RAYMOND H. FOGLER, ASSISTANT SECRETARY OF THE NAVY; COMDR. ROBERT E. LAUB, CHIEF, ELECTRONICS BRANCH, BUREAU OF AERONAUTICS, DEPARTMENT OF THE NAVY; TREVOR GARDNER, ASSISTANT SECRETARY OF THE AIR FORCE; MAJ. GEN. G. A. BLAKE, DIRECTOR OF COMMUNICATIONS, DEPUTY CHIEF OF STAFF, OPERATIONS, DEPARTMENT OF THE AIR FORCE; AND COL. J. F. TAYLOR, AIR FORCE, DIRECTOR, AIR NAVIGATION DEVELOPMENT BOARD

Mr. QUARLES. Mr. Chairman, I have, thank you.

May I, before taking up my prepared statement, say a few words of introduction to the topic?

We have attempted to be responsive to the interest of this committee in the rather limited time available, and we would like to lay before you the statements and the testimony that we are able to bring to you now.

We would like your indulgence if we haven't gotten everything you want, with the understanding that we will, of course, want to go back and be responsive if we haven't been able to do so in this time.

We are prepared to proceed in open hearing on the record, and while there may be some questions that will have to be reserved for executive session, I believe for the most part you will find that the proceedings can proceed on the record without any difficulty.

Mr. HOLIFIELD. Thank you, Mr. Secretary.

Let the reporter show that the following members of the committee are present: Mr. Hoffman, Mr. Riehlman, Mr. Lipscomb, Mrs. Griffiths, Mr. Garmatz, Mr. Dawson, and the chairman.

Proceed, Dr. Quarles.

Mr. QUARLES. If I may, then, sir, I will present my prepared statement.

Mr. Chairman and members of the subcommittee, I appreciate this opportunity to discuss the situation of the common system of air navigation with you.

Since this is my first appearance before this subcommittee as now constituted, I believe it will be helpful to give a brief statement of my background and experience. I was born in Van Buren, Ark., in 1894. After graduation from the high school there, I attended the University of Missouri and then Yale University where I received a Bachelor of Arts degree. In May 1917, I enlisted in the Army and, after 2 years in France and Germany, was discharged with the rank of captain in field artillery. Upon my return to civilian life in 1919, I was employed by the Western Electric Co. in New York City in the engineering department, which became the Bell Telephone Laboratories in 1925. While there, I took some graduate work at Columbia University in theoretical physics. I served the Western Electric Co. and the Bell Telephone Laboratories for 34 years in various engineering and executive positions, becoming vice president of the Bell Telephone Laboratories in 1948. I served in that capacity until March 1, 1952, when I became vice president of Western Electric Co., and president of the Sandia Corp., a Western Electric subsidiary which operates the Sandia Laboratory in Albuquerque, N. Mex., for the Atomic Energy Commission.

In addition to the military and industrial experience, I have served as a consultant to the Government on research and development activities since 1946. In that year, I was appointed a member of the electronics committee of what was then the Research and Development Board. I was chairman of this committee from 1949 until the termination of the Research and Development Board last year. I resigned as vice president of Western Electric Co., and president of the Sandia Corp., on September 1, 1953, in order to take the position of Assistant Secretary of Defense (Research and Development).

I would like to review for you the history of the Department of Defense participation in the development of a common air navigation system.

House Reports Nos. 59, 885, and 1065 of the 80th Congress advocated the development and installation of a system of navigation, traffic control, and landing aids—all to be common to all segments of aviation. These proposals were studied in detail by Special Committee 31 of the Radio Technical Commission for Aeronautics. This group, known as RTCA SC–31, was made up of top technical and operational representatives from industry and Government, including the military services, Commerce, Treasury, State, FCC, and the like. The group took the proposals in the House reports and developed a detailed program of action which was adopted by all classes of users of the airspace. This significant achievement resulted in RTCA being selected for the 1948 Collier award.

The Congress, through its Aviation Policy Board, endorsed the technical report and recommended that the program be launched.

Study showed that implementation of the program could be accomplished within the normal functions and responsibilities of the Department of Commerce and the Department of Defense without the necessity of seeking legislation to set up an independent governmental agency. Accordingly, by agreement between the two departments, the

Air Navigation Development Board was established in November 1948.

The Board, financed by funds provided by Congress in the Commerce Department budgets, undertook a development program which was worked on partially by direct contract with industry and partially by transfer of funds to the military services for work done on behalf of the common system.

For its part, the Civil Aeronautics Administration tackled the Federal airways implementation job with typical vigor and aggressiveness, with the result that as of the end of fiscal year 1955 there will be 436 VOR, 241 DME ground stations, as well as radar traffic control facilities in most metropolitan areas.

Mr. HOLIFIELD. At that point, Mr. Quarles, will you either explain what the initials VOR and DME stand for, or have one of your technicians explain that, for the record?

Mr. QUARLES. Yes, sir. This VOR–DME equipment, VOR is visual omnirange equipment, and DME, distance measuring equipment, which together constitutes the short range navigational system being installed on our Federal airways by the Civil Aeronautics Administration. VOR, visual omnirange, tells the direction of a plane from bearing points on the ground, and DME tells the distance of the plane from reference points on the ground, so as to enable the plane to know its position in space and navigate the airway.

Mr. HOLIFIELD. Thank you.

Mr. QUARLES. Now I would like to flash-back in time to pick up the TACAN story. If I may interpose there, TACAN is a coined word, TACAN, tactical system of air navigation is the origin of the word.

During the immediate postwar years there was an important military need for a carrier-based navigation system to replace the obsolescent equipment of the war years. A formal statement of the required military characteristics was adopted in February 1947, and the Navy commenced development of the system, now known as TACAN. This development was intended for what were important tactical uses and was carried on in a military security classification to preclude compromise.

The things that happened in 1949, 1950, and 1951—principally the Russian achievement in exploding an atomic device and our own involvement in the Korean conflict—served to intensify the military requirements and in no way relaxed the necessity for military security. Although the ANDB, ANDB being the Air Navigation Development Board, common system and TACAN were developing along lines that were technically incompatible, no one devised a way to bring them together. Had we gone into a full-scale war at that time probably no one would have brought them together. Actually the prospect of a head-on collision between the two seemed less important when the Federal airways were not clearly located in a potential battleground.

That is at the time when we were fighting on the field of battle being outside of the continental United States.

The end of the Korean conflict and the realization that we were in for a long pull in which our homeland might be on the front lines of an air war changed the situation. One of the first things I did upon coming on the job in the fall of 1953 was to work with Mr. Robert Murray, Under Secretary of Commerce, in recognizing the serious situation we were in any looking for ways to end the impasse.

Both the Departments of Defense and Commerce were firm in their support of the common-system concept but unyielding in support of their respective versions. The Air Navigation Development Board was reconstituted, still with Defense and Commerce as equal partners in the task, but with members from higher levels in Government. The revised charter was signed in January 1954.

I will offer, sir, a copy of the charter for the record.

Mr. HOLIFIELD. Without objection, it will be received.

(The document above referred to is as follows:)

CHARTER, AIR NAVIGATION DEVELOPMENT BOARD

Whereas the Secretaries of Defense and Commerce deem it essential that a single basic system of air navigation and traffic control—a truly national common system—must be developed and installed which will satisfy the requirements of all users to the greatest extent feasible, and

Whereas by means of a charter dated November 2, 1948, they established an Air Navigation Development Board to work toward this end, and

Whereas they now desire to reorganize this Air Navigation Development Board: Now, therefore, the Secretaries of Defense and Commerce have caused to be issued this charter which supersedes the charter of November 2, 1948.

1. THE BOARD ORGANIZATION

There is hereby continued the Air Navigation Development Board (hereinafter called "the Board") for the purpose of guiding the development of a common system of air navigation and air traffic control.

(*a*) *Board membership.*—The Secretaries of Defense, Commerce, the Army, the Navy, and the Air Force each shall designate a member and an alternate. Such membership shall consist entirely of personnel of policy stature.

(*b*) *Chairman.*—The Secretaries of Defense and Commerce shall jointly select the Chairman of the Board either from the Board membership or from other sources.

(*c*) *Full-time board staff.*—The Board shall have a full-time director and staff selected by the Board and appointed by the Secretary of Commerce with the concurrence and approval of the Secretary of Defense. The director shall be responsible to the Board for the supervision of its common system program and all related technical, administrative, and fiscal matters. The Secretary of Defense, the Army, the Navy, the Air Force, and Commerce each shall provide a full-time officer or official of appropriate rank who shall act as the direct representative of the designated board member of his department.

(*d*) *Location.*—The Department of Commerce shall provide all housekeeping services required by the Board and its staff.

2. POWERS AND DUTIES

(*a*) *Program and funding.*—The Board shall formulate, guide, review, and coordinate a unified program of research and development projects for the common system.

1. Each year the Board shall prepare a single comprehensive planned program of projects for the next fiscal year. This program shall include estimates of the planned funding requirements for each project.

2. The Board then shall determine the portions of the total program to be budgeted for by the Departments represented on the Board. The portion to be budgeted by the Department of Commerce shall include administrative funds required for the staff and operation of the Board.

3. Each board member shall seek budget coverage for that portion of the program assigned by the Board to his Department.

4. The Board, upon review of its program, shall make such revisions of the program and of the apportionment thereof among the Departments as the Board may deem necessary to achieve optimum use of available resources, and as may be practicable within appropriation limitations.

5. Funds appropriated for the program and administration of the Board shall be expended only for that program and administration as determined by the Board.

(*b*) *Operations.*—Under the direction of the Board, all common system research and development projects shall be contracted for or performed by the Departments of the Army, the Navy, the Air Force and Commerce.

(*c*) *Requirements.*—The Board, in formulating its program, shall be guided by operational requirements received from each of the Departments represented and from the Air Coordinating Committee. The Board shall integrate all these requirements to the maximum extent possible.

(*d*) *Security.*—The Board and its staff shall be authorized to receive, through approved channels, classified information concerning such techniques, facilities, and projects in the military departments as may be related to the fields of navigation and traffic control, and suitable provision shall be made for the safeguarding of such classified information in accordance with applicable Department of Defense security procedures and regulations.

(*e*) *Advice and assistance.*—The Board, to the extent practicable, should utilize the advice and assistance of Government and non-Government personnel concerned with the research and development, manufacture and use of aids to air navigation and air traffic control. The Board is encouraged to make maximum use of such groups as the Radio Technical Commission for Aeronautics.

3. PROCEDURE AND ADMINISTRATION

The Board shall meet formally at quarterly intervals at the call of its chairman, or at such other times as it may fix, and shall establish such rules of organization, procedure, and administration as it may deem necessary.

(*a*) *Policy of decisions.*—The Department of Defense and Department of Commerce shall have equal responsibility and authority on the Board. In the event of failure of the Departments of Defense and Commerce to reach agreement on any matter before the Board, it shall be referred to the Secretaries of Defense and Commerce who will make a determination.

(*b*) *Reports.* The Board shall submit reports of progress and any other items of interest every 6 months to the Secretaries of Defense and Commerce.

4. INTERIM OPERATIONS

The members of the Board at the effective date of this charter shall exercise the powers and perform the duties authorized by the charter until the membership of the Board as provided in this charter is appointed and assumes control by formal resolution.

5. EFFECTIVE DATE

The effective date of this Charter shall be the date of the later signature below.

C. E. WILSON,
Secretary of Defense.
SINCLAIR WEEKS,
Secretary of Commerce.

JANUARY 6, 1954.

Mr. QUARLES. The membership of the revised Board consisted of Under Secretary of Commerce for Transportation Robert Murray, Assistant Secretary of Navy (for Air) James H. Smith, Jr., Assistant Secretary of Air Force (R & D) Trevor Gardner, and the then Special Assistant to the Secretary of Army, Mr. James N. Davis. I was the Department of Defense member and chairman of the Board.

Now let me summarize the situation which confronted the new Board. The common system items, that is, the visual omnirange (VOR), which provides heading, and distance measuring equipment (DME), which provides distance information, were being installed at a rapid rate, with a total of 436 visual omniranges and 241 distance measuring ground stations budgeted for installation by the end of fiscal 1955. Parallel to this VOR–DME system was the TACAN development, which had reached the service test and evaluation point in its life cycle. We had reaffirmed the principle of a single navigation device system for civil and military use. If either TACAN or VOR–DME was to be chosen, it seemed imperative to the Board that

this choice be made as quickly as possible to prevent further commitment to either system. To continue both systems would have resulted in prohibitive cost and would have made the ultimate choice of a single system even more difficult than it then was. To complicate matters further, even had it been possible from the point of view of expense and space and weight in aircraft to install two systems, VOR–DME and TACAN, for basic technical reasons, those were incompatible to an extent that made full implementation of both systems impossible.

I would be glad to go into that further in executive session, sir, if you wish me to do so.

To assist in resolving these problems, the Air Navigation Development Board Advisory Committee No. 1 was appointed. This committee, later to become known as the VORTAC Committee, consisted of representatives from all the military agencies, the Departments of Commerce and Defense, the National Business Aircraft Association, and the Aircraft Owners and Pilots Association, with Mr. Milton W. Arnold, vice president for operations of the Air Transport Association, as chairman. Representation was deliberately planned to include all users of the air space, with voting privileges for each member.

It was realized that the VORTAC Committee decision would have to be based, to a large extent, upon the solution of technical and engineering complexities. Therefore, a team of consultants was made available to the committee. This team consisted of Dr. H. R. Skifter, president, Airborne Instruments Laboratory; Dr. J. B. Wiesner, Professor of Communications Engineering and Director, Research Laboratory of Electronics, Massachusetts Institute of Technology; and Mr. R. C. Newhouse, military development engineer, Bell Telephone Laboratories. These individuals are known to be outstanding in electronics and engineering sciences as applied to air navigation.

The VORTAC Committee, with its consultants, convened early in April 1954. It was immediately apparent, upon examination of all the evidence, that further engineering had to be accomplished upon the TACAN system. This problem was tackled by the consultants and, as a result of their efforts, engineering changes were made to the TACAN system which caused it to fulfill its early engineering promise.

Flight tests at Nutley, N. J., and at Caldwell, N. J., have confirmed the excellent work performed by these very fine people. Their findings in summary are:

The TACAN system will provide azimuth accuracy to within 1 degree, while the comparable VOR accuracy is 3 degrees.

Prior to any widespread use of TACAN, a study should be made to assure that it can provide the total number of interference-free channels required for common system operations.

The VOR, for basic technical reasons, cannot provide satisfactory service when installed on Navy carriers.

The VOR–DME system does not meet military needs for equipment which can be easily sited in military theaters of operation.

After due deliberation on the consultants' report, the VORTAC Committee split in its views with regard to choosing a single system. The majority opinion was for TACAN. Votes cast in the majority were from Army, Navy, Air Force, and Air Transport Association. The minority opinion was for continuing the VOR–DME program.

The Civil Aeronautics Administration, the National Business Aircraft Association, and the Aircraft Owners and Pilots Association were the minority.

At its January 14 meeting, Mr. Milton W. Arnold, chairman of the VORTAC Committee, reported to the ANDB; announced the inability of VORTAC to reach a unanimous decision; and described the majority and minority views. This left the Board with the basic navigation issue involved.

At this point, Mr. Chairman, if I may, I will introduce for the record the unclassified version of the report of the VORTAC Committee, which in turn contains the complete summary and conclusions of the consultants' report.

Mr. HOLIFIELD. Without objection, it will be received.

(The document above described is as follows:)

AIR NAVIGATION DEVELOPMENT BOARD—FINAL REPORT ANDB ADVISORY COMMITTEE NO. 1 (VORTAC COMMITTEE)

FOREWORD

The original classified edition of this report was prepared on January 5, 1955, and distributed to the Air Navigation Development Board for its consideration. On January 28, the Board arrived at its decision and directed that the report be declassified and made available to the press coincident with public announcement of the action taken by the Board.

This declassification has been accomplished herein by making a few deletions in appendices A, B, C, and E, of the report; no changes were necessary in appendix D.

JANUARY 5, 1955.

Mr. D. A. QUARLES,
Chairman, Air Navigation Development Board,
Washington 25, D. C.

DEAR MR. QUARLES: The members of ANDB Advisory Committee No. 1 herewith present their report to the Air Navigation Development Board.

We have had the able assistance of the three consultants appointed by the ANDB: Mr. Russell C. Newhouse, Dr. H. R. Skifter, and Prof. J. B. Wiesner. We have accepted their report to us as representing essentially the technica aspects of the problem, and suggest that they be commended for the excellent and painstaking work which is reflected in their report.

We regret that we were unable to reach a unanimous recommendation; however, in our report we have attempted to pinpoint the area of disagreement so that those who make the final decision will have available a brief, clear statement of the basic issue.

MILTON W. ARNOLD,
Chairman, ANDB Advisory Committee No. 1.

AIR NAVIGATION DEVELOPMENT BOARD

ADVISORY COMMITTEE ORDER NO. 1

TERMS OF REFERENCE

Whereas the Secretaries of Defense and Commerce, in the ANDB charter, have reaffirmed the requirement for one common military/civil system of air navigation aids; and whereas, there now exist in various stages of development and installation two systems of short-distance navigation aids, VOR–DME and TACAN, either or both of which may be capable of meeting existing military and common system requirements, the Board hereby establishes Advisory Committee No. 1 (hereinafter called the committee).

1. Objectives and responsibilities

Assemble and analyze factual information to determine the extent to which the VOR–DME and the TACAN systems meet, or can be made capable of meet-

ing, the technical and operational aspects of military requirements and common system requirements. The committee shall assure itself by review, guidance, and coordination of the evaluation projects undertaken by the Department of Commerce and by the military departments, that the evaluations are adequate and complete to the committee's needs in achieving its objectives. The committee may undertake any investigation into the economic or time factors involved in its conclusions and recommendations. It shall report its findings to the Board with such recommendations as it deems appropriate.

Findings

Neither system at present can meet all of the stated requirements. The TACAN system has high accuracy and shipboard performance potential—functions given the first priority by the military—but cannot provide a voice channel and will require reworking before it can provide high reliability—a function given first priority by civil aviation. On the other hand, VOR/DME provides the voice channel and the reliability, but, according to the consultants' report, it is not expected to meet the stated accuracy or shipboard performance requirements. Neither system will meet certain tactical requirements, as expressed by the Department of the Army, which will be required in the combat zone and are unique to that military service, but which may have a similar application to civil helicopter operations.

It is technically feasible to have coexistent fully implemented civil DME and partially implemented TACAN operations; however, due to mutual interference between TACAN and both DME and the Radar Safety Beacon, the coexistence of fully implemented civil DME and TACAN systems is not feasible.

(Note.—We have unanimously accepted the consultants' report as representing essentially the technical aspects of the problem. Copies of this report already have been forwarded to the ANDB, and no attempt is made herein to review or restate all of the material in that report. However, in appendix A we have quoted for ready reference the summary and conclusions section of the report.)

Recommendations

1. DECLASSIFICATION OF TACAN

We agree that complete declassification of the TACAN system should be accomplished as soon as possible.

2. VOR PROGRAM

We agree that VOR is the primary azimuth portion of the short distance Common System and should be maintained and improved until at least 1965.

3. ADOPTION OF TACAN

We disagree on the basic issue: adoption of TACAN as the Common System short distance navigational aid. The majority and minority positions are summarized as follows:

(*a*) Majority (ATA, Army, Navy, Air Force): TACAN should be adopted now as the common system rho-theta short distance navigational aid, with actual implementation to follow the completion of an ANDB-sponsored improvement program aimed at meeting Common System criteria not presently incorporated in the military TACAN system. A target date of 1965 for complete transition to TACAN is considered feasible. In the meantime, the VOR will continue to be the primary azimuthal aid until 1965, and the VOR program should be continued and expanded. However, the present civil DME program should be stopped immediately, and the ground equipment should be modified to work with airborne TACAN. This program requires the immediate and complete declassification of the TACAN system. The majority position is detailed in appendix B of this report.

(*b*) Minority (CAA, AOPA, NBAA): The present VOR/DME program should be continued and expanded as necessary. If a further development program on TACAN is undertaken, and if the results are successful, the matter then should be reviewed by all concerned to determine if TACAN should be adopted for the common system. The minority position is detailed in appendix C of this report. The AOPA and NBAA, in supporting the CAA position, presented the specific comments which are contained in appendices D and E of this report.

4. PUBLIC DISCLOSURE

We recommend that full and complete disclosure of all facts and circumstances not directly prejudicial to the national security, which led to the need for the VORTAC Committee, shall be made promptly after or, if possible, simultaneously with the announcement of the final decision by the Air Navigation Development Board. This information is needed to inform civil users of the background which led to the VOR–DME–TACAN controversy.

APPENDIX A

Quoted below is the summary and conclusions section of the consultants' report:

"A. Siting: The siting problems are different for each system, but both systems must be very carefully sited for maximum performance. The VOR requires a clearing of 1,000-foot radius, with the land quite flat, and all trees, fences, and other obstructions removed; even then, large objects more distant than 1,000 feet may cause large errors. TACAN is also difficult to site if the antenna is close to the ground. Sites that are satisfactory for TACAN are not necessarily satisfactory for VOR, and vice versa. However, TACAN siting problems are adequately overcome by elevating the antenna.

"B. Accuracy: The distance-measuring capabilities of both systems are similar and meet the stated requirements.

"We found the bearing accuracy of the modified (see appendix VI) TACAN system to be better than ±1°, if the antenna is mounted on a tower of sufficient height to clear nearby obstructions, and to provide an essentially line-of-sight path to the aircraft to be served. Further refinements of the TACAN equipments should provide a further increase in accuracy. Based on studies of the existing evaluation reports on VOR and all data furnished by CAA, the bearing accuracy of the present VOR system is considered to be better than ±3° when the VOR is sited in a properly cleared area. This accuracy would not be improved by mounting the antenna on a tower. Most of the serious VOR errors are due to site effects that are peculiar to the frequency and techniques of the VOR system. We do not know of any practical modification to the VOR system that will substantially increase its accuracy.

"C. Reliability: VOR ground and airborne equipments have proved highly reliable under the ultimate test—widespread operational use. Ground DME units indicate satisfactory reliability; although we have no significant operating data on the reliability of DME airborne equipment, it is reasonable to believe that it can be made to operate reliably.

"The present TACAN equipments are unreliable. Extensive reengineering of both ground and airborne units is necessary if they are to meet the standards of reliability generally associated with a common system basic navigational aid (see appendices IX and X).

"D. Colocation: There are two methods by which VOR–DME and TACAN might be colocated: coaxial and noncoaxial. Coaxial colocation of present VOR–DME and TACAN antennas is probably structurally impractical, and a substantial program of development and testing would be required to ensure that the VOR would not be adversely affected by coaxial colocation. Noncoaxial colocation at the same site within 1,000 feet would not affect TACAN performance but might affect VOR performance. Interference between the distance-measuring portions of the systems will be a problem (see secs. 2K and 4H). (The CAA advised us that if two navigation systems were to be used, the ground stations serving one location could be no farther apart than 1,000 feet without impairing the air traffic control system.)

"E. Size and weight: There is no significant difference between the size and weight capabilities of the two systems, except that the present VOR antenna-counterpoise system is much larger than the TACAN antenna. The TACAN airborne equipment is in one package; the VOR–DME is in two packages, but they could be combined. A lightweight low-cost azimuth-only TACAN airborne receiver comparable with the lightweight VOR receivers could be developed.

"F. Channel requirements: Either system appears to be adequate in this respect (see sec. 4H).

"G. Special applications: VOR performance is not optimum aboard ship because of siting and propagation factors. Reports of TACAN tests, with the antenna mounted on the masthead, indicate satisfactory performance.

"H. Timing: The VOR is partially militarized: the airborne units are fully militarized, and a military 50-watt surface equipment is available. The estimated time required to engineer, evaluate, and prepare production specifications for the various units is as follows:

Unit:	*Time required*
Shipboard VOR surface units	1 year.
Militarized DME surface and airborne units	12 to 18 months.
Ground and airborne TACAN equipments that will approach the VOR in realiability.	3 years.
Lightweight low-cost azimuth only TACAN units comparable with present lightweight VOR receivers.	2 years.

"The estimated time to engineer, evaluate, and prepare production specifications for coaxial colocation is 2 years. The time required for an interdepartmental cooperative test program to determine the effects of noncoaxial colocation within 1,000 feet upon the VOR is 4 months.

"I. Security: (Deleted).

"J. Communications: Simple voice identification could be added to TACAN by equipment modifications; however, TACAN cannot be expected to meet the requirement for two-way voice communications with aircraft.

"K. Frequency interference: Before making any plan for widespread use of TACAN, it would be necessary that the problem of interference with other services in the 960 to 1215 megacycles band be carefully studied and resolved."

APPENDIX B

DECEMBER 27, 1954.

AFOAC–E.

Subject: Majority Position for VORTAC Committee.

To: Chairman, ANDB Advisory Committee No. 1.

1. The military TACAN system should be adopted now for common system application. Actual implementation in the common system, however, will follow the completion of an ANDB sponsored improvement program to meet common system criteria not presently incorporated in the military TACAN system. The target date of 1965 for full implementation of TACAN in the common system is considered feasible.

2. A decision to adopt the TACAN system requires approval of the following courses of action:

(*a*) The immediate development of a plan for complete transition to TACAN as a primary rho-theta navigation system by 1965.

(*b*) The complete declassification of the TACAN system.

(*c*) The expansion of VOR facilities which will continue as the primary azimuthal navigational aid until 1965.

3. The development plan referred to in 2a above contains the following immediate steps:

(*a*) Development of a coverage and frequency plan to permit an area type of air traffic control. This is an immediate requirement for jet aircraft over 20,000 feet. The overall plan will reflect results of TACAN/VOR colocation tests and the 20,000-foot level presently required for jet aircraft will drop as transition progresses.

(*b*) The interim implementation by the military of minimum TACAN ground facilities in the United States in support of tactical operations.

(*c*) An expedited program to improve accuracy, reliability and maintainability of present TACAN ground equipment.

(1) The complete declassification of the TACAN system as soon as possible.

(2) The expansion of VOR facilities which will continue as the primary azimuthal navigational aid until 1965.

(*d*) The development of additional types of TACAN airborne equipment with a target date of 1957 to include:

(1) The development of a lightweight, simple model of an omnibearing, distance system to work with TACAN ground equipment. Integration of the two functions of azimuth and distance measuring in a single equipment will maximize savings in cost, weight and size and will provide an equipment for use in light aircraft such as the Army liaison craft, and Navy and Air Force trainers, plus civil aircraft. This development will also provide for:

(*a*) Design of a lightweight, simple model of an airborne distance measuring equipment to work with ground TACAN equipments. Two hundred and fifty of these airborne sets should be provided for a thorough long term in-service operational evaluation.

(*b*) Design of a lightweight, simple model of an omnibearing system to work with TACAN ground equipments. This equipment will be directly comparable in reliability, cost, weight and size to the present VHF omnibearing airborne equipments. One hundred of these equipments should be provided for a long term in-service operational evaluation.

(*c*) The modification of existing civil DME ground equipment to work with TACAN airborne equipment by 1957. Concurrently, ANDB should initiate a feasibility study for using modified Civil–DME ground equipments as low-powered terminal facilities by adding a TACAN azimuth capability, and if necessary as a result of this study, the development of a low-powered TACAN terminal aid.

4. The above position and the resultant course of action is based upon the following significant facts:

a. Technical facts

(1) Neither VOR–DME nor TACAN meet all stated requirements.

(2) The TACAN system is potentially capable of meeting the military's requirements for accuracy.

(3) Present TACAN ground equipments are not sufficiently reliable for unattended operation. However, the AN–URN–3 is designed for operation with monitors, alarm circuits, and dual units arranged for automatic switchover in case of failure.

(4) To include a voice channel capability in the TACAN system would preclude its present potential for data link utilization.

(5) TACAN will probably have a wider cone of confusion than VOR.

(6) It is technically feasible to convert present civil DME ground equipments to work with airborne TACAN equipment. Furthermore, reputable manufacturers have stated that commercialized versions of TACAN equipment can be provided within 2 years.

(7) After presentation of the consultant's report, Messrs. Newhouse and Skifter answered questions relating to its contents. During this period, several questions were asked related to adding pulsed azimuth to civil DME, adding CW azimuth to civil DME, and new developments compatible with civil DME. These consultants emphatically stated that any of these developments would be costly to the Government, would probably create a technically inferior system, and would create an intolerable time delay for development.

b. Operational factors

(1) The present Federal airways system of control is incapable of maintaining the desired safety of flight while expediting an increased air-traffic load. Basically this deficiency stems from the lack of adequate radar coverage, insufficient peripheral communications, poor data display and handling, and insufficient manpower. Implementation of air-traffic control procedures based on a distance measuring capability appears meaningless at this time, primarily because there are too few airborne users. Furthermore, to make a substantial improvement in the air-traffic control capability, distance measuring implementation appears to follow in priority the correction of the above listed deficiencies in the present system. Because of this lower priority and the fact that air-traffic control procedures must be based upon the equipments carried by the majority of the users, the cost of operating and maintaining civil DME facilities at this time could and should be better used to correct the higher priority deficiencies in present air traffic control.

(2) Specifically, CAA has stated that 50% or more of the users must be equipped before distance measuring can be expected to contribute substantially toward improvement of the air traffic control problems. In view of this statement, the following facts immediately become significant:

(*a*) Jet aircraft have an urgent requirement for a Rho-Theta navigation capability because their speeds and operating altitudes preclude effective use of the present report-over-fix procedures where such fixes are formed as intersections of azimuth courses.

(*b*) Above 30,000 feet there is only military traffic. Between 20,000 and 30,000 feet there is mixed airline and military traffic.

(*c*) Because of extensive use of "on-top" clearances by air traffic control for high altitude, high-speed aircraft, which, in effect, requires the observance of visual flight rules, air traffic, practically speaking, is uncontrolled above 18,000 feet.

(*d*) The military and the airlines state it would require 3 to 5 years to buy and install airborne civil DME in a majority of their aircraft.

(*e*) The military and the airlines comprise more than 80 percent of instrument air traffic in the United States.

(3) An analysis of the above facts leads rather forcefully to a conclusion that the civil DME can cause no appreciable improvement in air traffic control for 3 to 5 years. On the other hand, the introduction of distance in 1957 through the TACAN program would offer the following advantages:

(*a*) The quickest means of getting distance-measuring equipment in the military aircraft.

(*b*) The airlines could if desired obtain and install a TACAN type airborne equipment in a 3- to 5-year period.

(*c*) The upper altitudes afford a stratified area where procedures for an area type of control can be effectively proved operationally.

(*d*) Area control can be implemented at lower altitudes as other users are equipped for Rho-Theta navigation.

(4) In an area type of control based on Rho-Theta information the size of the cone of confusion is relatively unimportant.

(*c*) *Other factors*

(1) Economically, the decision to adopt TACAN and to eliminate civil DME techniques at this point will result in the least cost to the Government.

(2) Elimination of civil DME techniques at this point has 4 additional advantages:

(*a*) Precludes additional investment by civil users for equipment and maintenance.

(*b*) Avoids a serious channel availability and interference problem which could adversely affect the defense of the country.

(*c*) Prevents a problem in discontinuing civil DME at some date in the future after many, no longer few, users may have installed civil DME airborne equipments.

(*d*) Is a positive step toward a truly common system by insuring that the distance measuring capability will be based on a single technique.

(3) Permits a continued existence and expansion of the VOR system to serve as the primary azimuthal Navaid until transition to the TACAN system.

5. The undersigned members of the ANDB Advisory Committee No. 1 support the above position for the reasons listed.

MILTON W. ARNOLD,
Air Transport Association.
J. L. WILSON,
United States Army.
H. A. FRENCH,
United States Air Force.
JAMES T. PYLE,
United States Navy.

APPENDIX C

DECEMBER 22, 1954.

CAA VORTAC POSITION

The following position is predicated on the facts that have been developed, including the consultants' report, and avoids recommendations based on speculation. This position is, therefore, recommended for adoption as the position of the VORTAC Committee. The position is as follows:

(*a*) The present VOR–DME program should be continued and expanded as necessary.

(*b*) If any further development of TACAN is undertaken to resolve the problems so far identified, such development should be handled with the proper coordination of all concerned so that all of the stated agency requirements may be given the proper attention.

(*c*) If such a development program on TACAN can be successfully completed, the results should then be reviewed by all concerned to determine if TACAN should be adopted for the common system.

(*d*) Since the military have stated an immediate requirement for a limited number of TACAN installations for evaluation and other purposes, the planning for these installations should be properly coordinated to avoid interference with VOR–DME.

The following is a brief résumé of some of the facts leading to the above position. These facts are essentially derived from or confirmed by the Consultants' report. The technical references given below are references to this report unless otherwise indicated. The most significant of these facts are:

(*a*) The consultants estimate that the additional TACAN development will require a period of about 3 years. Assuming that this conservative estimate is valid, and since experience shows that a new system cannot be expected to be operationally available to all users for 10 years after completion of development, it is evident that the adoption of TACAN at this time would not result in an operationally available system before 1965—probably not before 1968. TACAN, furthermore, cannot provide a voice channel and inherently has a wide cone of confusion (vol. 1, p. 13, par. B–4; vol. 1, p. 21). With respect to these two items, therefore, TACAN will not meet the stated requirements even after development is successfully completed.

(*b*) The VOR–DME system is essentially in being. The VOR portion of the ground system is completely installed and commissioned except for such additions and modifications as are required from time to time by operational needs. The DME portion of the ground system is essentially complete and can be fully commissioned within 1 year. A large percentage of the users are equipped with airborne VOR and equipment is available on the commercial market for those not yet equipped. Airborne DME equipment is available and airborne implementation is dependent entirely on the desires of the users.

(*c*) There is an immediate operational requirements for distance information. As indicated above, this requirements can be satisfied immediately with civil DME, subject only to user implementation. The adoption of TACAN, on the other hand, would prevent the satisfying of this operational requirement for at least 10 years.

(*d*) With respect to the distance measuring functions, civil DME meets all of the stated requirements (vol. 1, p. 15, par. D).

(*e*) With respect to the azimuth accuracy requirement, the consultants' report states TACAN appears to have more potentialities than VOR under certain military conditions (that is, shipboard use and field conditions requiring ability to set up a facility within 2 hours). Actual experience with VOR's indicates that for civil fixed installations, proper conditioning of the site results in VOR accuracy of the same order as that anticipated with TACAN. Civil aviation does not require this potential accuracy (vol. 1, p. 5, item C–46, figs. 1, 2, 3).

APPENDIX D

AIRCRAFT OWNERS AND PILOTS ASSOCIATION,
Washington 14, D. C., December 30, 1954.

BRIG. GEN. M. W. ARNOLD,
Chairman, Advisory Committee No. 1,
Air Navigation Development Board, Washington 25, D. C.

DEAR GENERAL ARNOLD: AOPA generally supports the position taken by the CAA in the VOR–DME–TACAN dispute. This letter is intended to amplify AOPA's position.

It should be clearly understood from the outset that AOPA participated in the VORTAC Committee in good faith, and that we devoted all the time and effort that was required in an effort to assure the fairest possible decision. It was quickly apparent to us, however, that a fair and factual decision would be impossible to reach, and we repeatedly made that point throughout the VORTAC deliberations. This was due entirely to the fact that the Air Force, Navy, and Army participated in VORTAC from the very beginning on this basis:

1. TACAN is firmly and irretrievably committed for military adoption, and on a tremendous and costly scale.

2. Civil aviation and the common system can do nothing to change this fact. Further, civil aviation had best "get on the bandwagon" and agree to the adoption of TACAN and the ultimate replacement of VOR–DME. Failure to do this among ourselves, we were told, could only and inevitably result in Congress forcing us to do so. In this latter eventuality, the military pointed out, Congress presumably

will refuse to finance two separate systems, and will automatically insist without question that the military position is the right position, and hence civil aviation will be forced to comply.

Essentially, this is the atmosphere that quickly became apparent in the VORTAC Committee. All the discussions and studies within the committee were predicated on that immovable foundation. It was for that reason that AOPA felt from the beginning that the VORTAC Committee could actually accomplish little.

AOPA's original understanding was that VORTAC would operate on a fair, impartial, and equal basis. We felt that both VOR–DME and TACAN would be studied on a fair and equal basis, and that the facts gained from such a study would be the sole basis on which the ultimate decision of whether VOR–DME or TACAN would best fit the common system would be made. This proved to be untrue.

In AOPA's opinion, the only thing within VORTAC that could have changed the military position one iota would have been a flat, unequivocal condemnation of TACAN by the technical consultants. That such condemnation was not forthcoming in connection with either VOR–DME or TACAN is simply proof that the consultants did a thorough and expert job, as no reasonable navigational system—even one as sketchily developed as TACAN—would be branded as being wholly bad by such men.

Everyone quickly read into the consultanfs' findings what they wished. The military contend the report endorses TACAN, with a few cleaning-up details. The CAA feels otherwise. OAPA feels the consultants' report makes it quite clear that TACAN, after the expenditure of many millions of dollars, still cannot even approach the present-day performance of the VOR–DME system already in being. That TACAN can ever surpass the performance of VOR–DME in actual operation is clearly a matter of speculation. In addition, TACAN already has at least one grave common system deficiency in that it offers no voice communication facility.

AOPA feels strongly that the consultants' report adds up to a situation that points to such grave deficiencies in TACAN that the solution of these problems is actually a mater of speculation. Many unexpected thousands of dollars even had to be spent by the consultants during their investigations for the sole purpose of bringing the basic TACAN system to a point where they could reliably measure it. Based on data presented to the VORTAC committee, we are convinced that many millions of additional dollars will have to be spent in an effort to make TACAN meet performance standards which the military had already claimed for it, but could not demonstrate

AOPA is seriously concerned with the fact that the VORTAC Committee proved to be little more than a sounding board for the fixed, unequivocal-military position. At no time was it a fair and impartial deliberation, with everyone facing the facts and acting upon them with no predetermined position.

Assuming as we must that the mere existence and daily operation throughout the United States of the VOR–DME system indicates that that system is "right"—at least in the eyes of the taxpayers and Congress, who appropriated the money needed o bring the system into being—the atmosphere in the VORTAC meetings was simply one based on the theory that "might makes right." With the armed services lined up solidly in a determined position to force TACAN into being, all civil aviation was faced with the flat military position that the Armed Forces are dedicated solely to the purpose of ultimately replacing VOR–DME with TACAN. And AOPA disagreed sharply with the contention of the military that their TACAN program will not spell the end of VOR, and that only DME will suffer immediately. AOPA is firmly convinced that the program proposed by the military will, if adopted, immediately and automatically spell the end of not only DME but VOR as well. The only difference will be that the end of VOR will be more gradua. Other than that, however, it is AOPA's contention that VOR would immediately become the secondary system in the eyes of Congress and the Bureau of the Budget, and that every effort would immediately turn to tapering VOR and conceutrating further expenditures for nav aids to TACAN. Actually, this is precisely the fate that has befallen the LMF four-course radio ranges today. None but the most vital expenditures for these low-frequency ranges is approved any longer.

The decision thus appears to rest on whether or not the sheer weight and power of the military will decide this matter, without regard for the facts or cost. It is AOPA's earnest hope that, somewhere in the higher Government levels that will have to make the final decision, a fair and impartial evaluation will be made.

At the same time, we recognize the gravity of this decision. Whichever way it goes, it is going to cost the American people vast sums of wasted money.

This fact alone, AOPA feels, warrants the closest possible scrutiny of this entire controversy by the highest Government authorities. It is AOPA's opinion that this costly controversy never would have come about had not some branches of the Armed Forces improperly and perhaps illegally committed tremendous sums of money for a system of radio navigation that was—and still is—highly speculative.

AOPA also is concerned with the fact that these commitments were made during a period when these same branches of the Armed Forces were committed to the common system, the system which Congress approved.

Meanwhile, it is apparent to AOPA that one of the most important reasons civil aviation has been forced into this controversy is the fact that the current blueprint for the common system indicates that the system must meet the tactical requirements of the military. The primary justification for forcing TACAN into the common system is its claimed ability to enable fighters to attain a higher percentage of successful interceptions of unknown aircraft, and the ability of TACAN to serve carrier-based Navy aircraft at sea. AOPA attaches the greatest importance to these requirements as tactical military necessities. But AOPA also questions the wisdom of attempting to force all civil air commerce to accept such exclusively military considerations as the overriding justification for destroying a substanial, costly part of the existing common system. If we continue to abide by such a policy, doggedly and without reevaluation, where will this lead us? Must civil aviation soon prepare to convert to still another system, this time required to operate pilotless guided missiles in the airspace?

AOPA feels this TACAN controversy itself may well serve as the basis for the first major change in the common system concept since it was conceived by SC–31. The all-important reasons for pushing TACAN are purely military. AOPA feels the time has come for a sharp delineation between tactical military requirements, and the continuation, development, and expansion of civil aviation in the United States.

AOPA urges the fullest public disclosure of the facts that led to this controversy. We feel the public must have the facts behind any controversy which involves a total expenditure of Government funds of more than a half-billion dollars.

Sincerely,

MAX KARANT,
Assistant General Manager.

APPENDIX E

NATIONAL BUSINESS AIRCRAFT ASSOCIATION

NBAA POSITION—VORTAC COMMITTEE

I. As a matter of record, NBAA concurs in general and votes to support the position and report of the CAA on the Vortac Committee. The purpose of this report is to substantiate and amplify the position taken by NBAA.

II. Objectives and responsibilities: The terms of reference set forth by the Air Navigation Development Board in establishing Special Advisory Committee No. 1, hereinafter referred to as the Vortac Committee, read as follows:

"Assemble and analyze factual information to determine the extent to which the VOR–DME and TACAN systems meet, or can be made capable of meeting, the technical and operational aspects of military requirements and common system requirements."

It will be noted that the ANDB specifically separates "military requirements" and "common system requirements." This differentiation is quite proper, since it is in accordance with the original concept of the common system as set forth in SC–31 report and subsequently followed by all properly established committees as accepted terms of reference to the common system; that is, that there would be tactical military requirements which the common system could not, and would not, be expected to meet.

III. Conclusion: NBAA has very carefully studied and analyzed all of the facts and information available to the Vortac Committee, and our final conclusion is that neither VOR–DME or TACAN meet the operational requirements as set forth in the Air Navigation and Traffic Control Panel Report, No. ACC–59–58B, "Statement of Common System Operational Requirements for Short Distance Navigation System." It is our conclusion that VOR-DME does meet the

operational requirements of the common system if certain clearly tactical specifications of the military are relieved.

NBAA does not believe that it is to the best interests of national defense to link tactical operations to common or public navigation systems. For example it seems inconceivable that the Navy would want to establish on board an aircraft carrier the same kind of surface navigation station as used in the common system, since this would make it possible for any enemy aircraft using commercially available equipment, even manufactured by ourselves, to accurately navigate directly to that carrier. Conversely, if tactical requirements are to be arbitrarily imposed upon the civil users by the military, as they are trying to do in this case, then it would be just as logical to require every civil aircraft to equip itself with navigation equipment and devices which are peculiar to meet the operational requirements of launching and navigating guided missiles to their targets.

IV. Recommendations: 1. Continue to improve and expand, as necessary, the present VOR–DME system.

2. In accordance with the original common system plan, develop a 1000-megacycle CW omni system, which not only can be utilized with the present DME, but which also is compatible with the other devices operating in the same frequency band. This system should have shipboard operating capabilities and be designed in such a manner as to meet all other present common system operational requirements. We do not believe that the development of this system would involve any appreciable delay over the TACAN system so far as availability is concerned, since at least 3 years more of engineering development work would still be required on TACAN. Also, in view of the experience and research "know-how" developed in the past few years, this system could be developed with a minimum of delay and technical problems. The implementation of this system could be undertaken without any interference, confusion or interruption to the operation of the common system.

3. Development work by the ANDB should be undertaken for the development of the ultimate navigation system of the common system in the 2500- and 5000-megacycle range, whichever seems most appropriate. The state of the art and electronics engineering research work that has been done to date indicates that the ultimate requirements of the common system will have to be met in a higher frequency band than the present 1000-megacycle band. Both the 2500- and 5000-megacycle frequency bands have been set aside for aviation navigation aid operational uses. Since some research and development work has already been done in the 5000-megacycle range, it would probably be more advisable to work in this frequency band.

4. Consideration of TACAN as the common system component should be abandoned. Any military uses of TACAN for tactical purposes in the Z. I. should be limited to those frequency channels which do not interfere with the operation of the present common system. Implementation of any TACAN stations should be coordinated with the Federal airways to assure that interference is not encountered.

5. In the future, all development work by all users of the airspace should be coordinated through the ANDB, in order that a repetition of the TACAN situation with its colossal waste of the taxpayers' money can be avoided.

V. NBAA is opposed to the adoption of TACAN as the primary short distance navigation component of the common system for the following reasons:

1. *General.*—From the outset, the development of TACAN has been carried on with the full knowledge that it was incompatible with the officially established common system. This development work has been carried on surreptitiously and in spite of the fact that the military agency sponsoring its development had agreed to and accepted the present common system in properly established committees which coordinated the development of the common system. We are astounded at the millions of dollars that have already been expended on development of TACAN under these circumstances. Furthermore, we are also amazed that so much money and time could have been expended on anything and the state of development of the device to be so far from completion.

2. *TACAN is not developed.*—According to the consultants' report, at least 3 more years would be required to complete the necessary development work on TACAN. TACAN is so poorly developed at this time that it was necessary for the consultants to spend a considerable amount of money and time in making modifications before the TACAN units were usable in their tests. The delay due to making these modifications set back this committee's report at least 6 months.

3. *TACAN equipments are unreliable.*—This is a direct quotation from the consultants' report. In discussions with the Vortac Committee, the consultants stated

that at the outset of their tests they were astounded at the lack of performance and poor reliability of TACAN equipments.

NBAA submits that reliability is the first and compelling requirement of any common system equipments. All other operational requirements are secondary.

4. *TACAN does not provide voice communications.*—This is an essential requirement of the civil users of the common system, and TACAN cannot be made capable of meeting this requirement.

5. *TACAN does not provide instrument landing system capability.*—This also is an essential operational requirement of the civil users of the common system. The adoption of TACAN as the common-system equipment would merely mean that in a complete and operationally usable civil airplane the TACAN equipment would be in addition to all of the equipment presently required.

6. *Weight and size.*—Since TACAN does not provide all of the operational capabilities as does VOR–DME, such as voice communications and ILS functions mentioned above, the size and weight of the two systems cannot be properly compared. Collins Radio Co. has estimated that the distance portion only of TACAN would be twice as large as present DME units and would weigh 55 pounds compared to 29.9 pounds for current production DME's. It is reasonable that the same ratios of size and weight would apply to the azimuth portion of TACAN as compared to civil VOR receiver units.

7. *TACAN ground stations require attended operation.*—The complexity and unreliability of TACAN ground installations require a full-time operating technician on duty. On the basis of the number of presently established VOR stations in the United States, the manpower requirement for an equivalent number of TACAN stations would be approximately 2,000 technicians. There have been "promises" by the military proponents of TACAN that unattended ground station operation could be obtained, but there is no factual information to indicate that this is possible.

8. *TACAN units would be too costly for civil users.*—Due to the complexity and size of the TACAN equipment, NBAA does not believe that airborne units could be produced and sold at a price which the civil users could afford to pay. The only factual information available so far has been an estimate by the Collins Radio Co. that the distance portion only of TACAN could be produced for approximately $4,000, net cost, in lots of 1,000 units. This would be in addition to a tooling cost of over $500,000. This compares with the present net production cost of $2,569 for civil DME by Narco in lots of 100 units and without any military assistance. Since these are net production costs, it is reasonable to assume that selling prices for TACAN units, due to the retail dealer markup required, would be at least double the present selling prices of DME's. Also, it is reasonable that the azimuth portions of TACAN would likewise cost at least double or more than present VOR equipments.

9. *TACAN does not have adequate coverage.*—The power output on TACAN units as presently developed is not adequate to provide the spatial coverage as set forth in the operational requirements of the common system. Such an increase in power obviously will mean increased cost and increased size and weight of unit.

10. *TACAN interferes with other devices besides DME.*—TACAN would interfere frequency-wise with other devices which are already in use by the military. Since DME does not use the entire available frequency band, it is possible to operate these other devices in the same frequency range without interference. There seems to have been some misconception that only DME and TACAN were incompatible.

11. *TACAN has an error characteristic inherent in the design.*—The use of a nine-lobe signal in TACAN makes it possible for the equipment to "jump sectors." This phenomena has been observed in the tests conducted so far. The consultants have stated that there does not appear to be any practical method of monitoring the airborne equipment so as to signal the pilot when this malfunction occurs. NBAA submits that this "sector jumping" characteristic more than offsets the potentially higher accuracy of the nine-lobe signal of TACAN over the single-lobe system of VOR.

VI. NBAA endorses the continuation of VOR–DME as the primary navigation aid components of the common system for the following reasons:

1. *General.*—The common system has been developed in a proper and orderly manner, and thoroughly coordinated with all users of the airspace, and it has been adopted and accepted by all users of the airspace including the military agencies now advocating TACAN. There has been no new facts of sufficient

importance submitted to the committee to justify any deviation from the common system as presently established. The common system has not been expected to meet tactical requirements in the past, and we do not believe that it should be expected to meet these requirements in the future.

2. *The system is developed.*

3. *The system is reliable.*—The consultants stated in their report, "VOR ground and airborne equipments have proved highly reliable under the ultimate test—widespread operational use. Ground DME units indicate satisfactory reliability. Although we have no significant operating data on the reliability of DME airborne equipment, it is reasonable to believe that it can be made to operate reliably." Since NBAA members presently own and operate over 90 percent of all the DME units that have been produced, we can state that this operating experience with production units has indicated satisfactory reliability of the airborne units.

4. *The system is implemented.*—Since most business flying is done "off airways," we have a greater requirement for rho-theta type navigation information than any other civil user. It is essential that this type of navigation information be available now to meet present needs and so that the future potential growth of business flying will not be handicapped. It would be at least 8 to 10 years at the very best before any other type of new navigation system would be completely implemented on a scale sufficient to meet civil requirements, and as a matter of practical consideration, we cannot comprehend any action which would preclude the use of the present completely implemented, existing proven system on the basis that something may be developed in the future which might be better.

5. *VOR–DME is an integrated system.*—VOR–DME meets all of the operational requirements of the civil users of the airspace. In addition to rho-theta information, it also provides communications as well as ILS navigation information. The accuracy requirements of civil aircraft users are adequately met with the present system. NBAA does not believe that aircraft can be flown within the limits of accuracy as set forth as a requirement by the military.

NATIONAL BUSINESS AIRCRAFT ASSOCIATION,
COLE H. MORROW, *Vortac Committee Member.*

COMMITTEE ROSTER

Air Transport Association, Mr. Milton W. Arnold (Chairman), Vice President, Operations-Engineer, ATA.

Department of Commerce, Mr. Peter Caporale, Chief, Airways Engineering Division, Office of Federal Airways, CAA.

Mr. D. M. Stuart, Alternate, Director, Technical Development and Evaluation Center, CAA.

Department of Defense, Mr. E. C. Wood, Department of Defense Representative, ANDB.

Aircraft Owners and Pilots Association, Mr. J. B. Hartranft, President, AOPA.

Mr. Max Karant, Alternate, Assistant General Manager, AOPA.

National Business Aircraft Association, Mr. Cole Morrow, Chairman, NBAA.

Mr. Jean DuBuque, Alternate, Executive Director, NBAA.

Department of the Army, Lt. Col. J. L. Wilson, Chief, Aviation Section, P. & O. Division, SIGOP–5.

Dr. William Young, Alternate, Assistant Chief, Aviation Section, Office of Chief Signal Officer.

Department of the Navy, Mr. J. T. Pyle, Special Assistant, Civil Aviation, Assistant Secretary of the Navy for Air.

Cdr. R. L. Eldridge, Alternate, Head of Air Navigational Aids Branch, CNO, Op–534.

Department of the Air Force, Col. H. A. French, Chief, Electronics System Division, Directorate of Communications.

Lt. Col. Philip Cobb, Alternate, Chief, Ground Base Reference Navigation Section, Instrument Navigation Bombing Branch, Directorate of Research and Development.

Mr. B. A. Denicke (Secretary), Air Navigation Development Board.

Mr. HOLIFIELD. The classified part will be presented in executive session, I understand.

Mr. QUARLES. The classified part will be available to you, sir, in executive session.

Upon review of the report of the VORTAC Committee, and the reasoning behind it, Mr. Murray, then Under Secretary of Commerce for Transportation and Department of Commerce member of the Air Navigation Development Board, suggested consideration of an alternative course of action, which had not been included in the terms of reference of the VORTAC Committee. Following this suggestion, an ad hoc group was appointed to investigate a system composed of civil DME, which as a component, met military requirements, plus an azimuth system yet to be developed. This new azimuth device would be located in a higher frequency band than TACAN and would satisfy the military requirements for 1° accuracy, be suitable for fleet use, and could be sited in military field environments.

The ad hoc group reported on an alternative course of action to the Air Navigation Development Board at its January 28 meeting. This system used civil DME and an azimuth system in the 1365–1660 megacycle band. Because of the additional expense and a further delay of approximately 3 years to ultimate common system implementation, this system was not favored by ANDB as first choice.

The Board now found itself in a most perplexing situation. Neither VOR–DME nor TACAN nor the best alternate system, was acceptable to everyone.

Also, the Board had substantial uncertainties which needed to be explored and resolved before final standardization of TACAN could be effected. Matters to be explored included:

The determination of the final requirements for the common system in relation to available frequency space in the TACAN band.

The relationship between the common civil/military short-range navigation system, and the electronic ground environment being developed for our air defense system.

The international implications of any standardization move.

The Board was of the opinion that the best escape from this dilemma was to outline a plan of action which would declare a system objective and would discourage further commitment to the system not singled out as the Board's intended choice. The action had to serve the best national interests, recognize the uncertainties that were inherent in the systems under review, but also provide a means by which final decision was reserved for the future when present intangibles became more clearly defined.

The ANDB decided unanimously on the following course of action:

1. Finish the development of TACAN to make it suitable for common system use at the earliest practicable date.

2. Continue VOR as a common system navigation aid at least until 1965.

3. Limit the use of civil DME facilities to experimental purposes, with the understanding that DME service is not guaranteed beyond June 30, 1955. (This is to assure that DME frequencies would not stand in the way of TACAN if it later is standardized.)

4. Permit military agencies to implement TACAN facilities to meet their minimum interim requirements, for the present, on a basis which will be noninterfering with channels assigned to the civil DME and the Common System Radar Beacon.

5. As a "backup" for the TACAN program, in case it should later prove unacceptable or inadequate for any reason, finish the design of the alternate proposal. This would consist of the present civil DME

to provide distance plus a new CW omnirange—that is a continuous wave, omnirange—device to be developed for a more suitable frequency band, as recommended by the consultants. The DME ground equipment will be held in readiness for this eventuality.

The Board's reasoning in stating that it could not guarantee DME service after June 30, 1955, deserves explanation. TACAN had been favored in the Board's plan of action over VOR–DME. As I previously stated, TACAN and DME are mutually interfering; it did not appear to the Board that a navigation aid interfering with TACAN could be allowed to continue indefinitely. Also, DME, although about 50 percent implemented with commissioned ground stations, has not been accepted generally by the aviation public. We understand that approximately 250 airborne equipments have been built; we have estimates of the number of airborne sets that have been purchased by aircraft owners from as low a figure as 90 to as many as 220.

And I may say, sir, that this number compares with forty or fifty thousand of the VOR sets that have been purchased by aircraft owners, and for the most part installed. So that the number of DME sets that already have been purchased by aircraft owners is relatively very small.

Mr. HOLIFIELD. Well, of course, with the threat of extinction of this system hanging over their heads, you can readily understand their lack of enthusiasm for buying something which can't be used after June 30 of this year.

Mr. QUARLES. That's right, sir. That threat was perhaps highlighted by the actions of the Board and most of these purchases were made at an earlier time, but your statement is nevertheless correct.

Mr. HOLIFIELD. And it is true that the Air Force itself has bought about 28,000 of these sets; is that not true?

Mr. QUARLES. Are you speaking of VOR? The Air Force itself has bought only a very few DME equipments, sir.

Mr. HOLIFIELD. That refers to the VOR sets?

Mr. QUARLES. But the Air Force had purchased VOR equipment in substantial quantity, and we will cover that, if we may, in a later presentation.

An unknown number is still in the hands of dealers. The remainder of these equipments were purchased by the ANDB and Civil Aeronautics Administration for experimental and evaluation purposes. The Board felt that with TACAN as the announced objective, plus the interference problem between TACAN and DME, it was doubtful that Congress could be properly asked to appropriate funds for DME operation on an interim basis, in the interest of such a small segment of the aviation public. We were also anxious not to encourage more purchases of airborne equipment in view of the doubtful future of DME. The Board did, however, consider other DME possibilities, such as:

1. DME could be kept in operation until the time of final transition to the chosen system when, if the preferred system were TACAN, DME would be shut down. Disadvantages to this course were that it would require the interim military use of TACAN to be limited to 50 channels; also, it would tend to encourage additional purchases of airborne equipment, which would make the final shutdown of DME difficult.

2. An interim operation for 2 or 3 years on an experimental basis, in order to establish traffic control procedure and train traffic controllers and pilots in the use of distance information as a traffic control and navigation aid.

3. Maintain DME in a condition of readiness so that if TACAN proves to be inadequate or unsatisfactory for common system use, DME could be used to provide distance information in the alternative system to which I have already referred.

It was the latter consideration that the Board thought most reasonable because it involved the least expenditure of public funds and yet provided for a part of the "backup" system for TACAN if it failed to qualify.

Finally, it was the Board's unanimous conclusion that the five-point program that has been announced and which I gave you a moment ago, was the best that could be made of a very complex situation for which there appeared to be no completely satisfactory solution. I believe this course of action is the least costly to the taxpayer, best satisfies the needs of both national defense and civil aviation, and minimizes further expenditure for equipment having limited utility. Finally, it promises a much improved common civil/military system of navigation by the implementation of TACAN which, even with the uncertainties already mentioned, has the greatest potential for common system use.

That, sir, completes my prepared statement.

I realize that I have dragged your committee through a very intricate situation. I have attempted to make it as clear as I could, but I am afraid that it still has a lot of mystery about it.

If I could help any by answering questions to clarify it, or if our others who are here could help, we will certainly be glad to do so.

I might say at this point, sir, that Mr. Raymond Fogler, Assistant Secretary of the Navy for Materiel, is prepared to present a statement to you covering the TACAN development and procurement history.

The Navy has been responsible for this development and has been within the Department of Defense the responsible agency for the procurement of TACAN equipment for all uses, including the Air Force uses.

Mr. Trevor Gardner, Assistant Secretary of the Air Force for Research and Development, is also here to discuss the Air Force plan in relation to this program in response to the subcommittee's expressed interest in this matter.

You can, as the committee may choose, let these gentlemen present their material and then have questions; or if you would like to do so, sir, I will attempt to answer any questions you would like to ask in relation to the overall situation now.

Mr. HOLIFIELD. Thank you very much for your statement, Secretary Quarles. I believe that it might be wise to have Mr. Balwan ask a few questions. He has been studying this matter. We assume, of course, that the military people know what we are doing and there are some unanswered questions, because of allegations that have been made before this committee as to the lack of wisdom in this program, and so at this time I will ask Mr. Balwan, the director of our staff, to ask you a few questions before the other presentations are made.

Mr. QUARLES. All right, sir.

Mr. BALWAN. Mr. Secretary, did the Air Navigation Development Board know that TACAN was being developed by the Navy as the common system was being worked out?

Mr. QUARLES. Yes, it did. Members of the Air Navigation Development Board knew of this development. The development was classified under security, and the development itself was not made available to the Board officially for that reason, but members of the Board knew of this development.

Mr. BALWAN. The Board would know of its development primarily because 4 of the 5 members were military people?

Mr. QUARLES. Four of the 5 members have been military people since the Board was reorganized at the end of 1953, that is correct, sir, but in any case, even in the earlier Board, there were Department of Defense and military members.

Mr. BALWAN. And how many members do we have to represent the civilian aviation interests on the Board?

Mr. QUARLES. In the present organization of the Board and in the past organization of the Board, there were members from Defense and from the Department of Commerce, with one vote for each group.

Since the Board was reorganized, there were 4 members from Defense and 1 member from Commerce, but they had as a group 1 vote from each Department.

Mr. BALWAN. So it was a two-vote proposition?

Mr. QUARLES. Two votes; that is correct.

Mr. BALWAN. And that was true before Reorganization Plan No. 6?

Mr. QUARLES. Commerce and Defense had equal votes in the Board in the earlier organization of the Board, I believe, sir.

Mr. BALWAN. And the Department of Commerce representative knew throughout the development of the common system that TACAN was being developed by the Navy?

Mr. QUARLES. I would be testifying on hearsay there, but I believe that is correct.

Mr. BALWAN. How does the Air Navigation Development Board work? I mean, there is a Board, but do you have a staff of any kind, or a secretary?

Mr. QUARLES. We do have a staff, sir. Colonel J. F. Taylor, who sits at my right, is the Director of the Board, and Colonel Taylor, as Director, has a staff under him that studies these programs and carries out the affairs of the Board.

Mr. BALWAN. Is Colonel Taylor on active duty?

Mr. QUARLES. Colonel Taylor is on active duty, in the Air Force, and is detailed to this operation.

Mr. BALWAN. And what is the composition of the ANDB staff? Is it primarily military people, or do you have other aviation interests?

Mr. QUARLES. There are assigned to the staff, from each of the members, that is, from Defense, Army, Navy, Air Force, and Commerce, representatives of those members, who work on the staff. Of those five people, three of them are military and two are civilian.

My representative is civilian, Commerce representative is civilian, the Military Department's representatives are military. Aside from those representatives, there is a regular staff, permanent staff, all of whom are civilian.

Mr. BALWAN. Where is the office of the Air Navigation Development Board?

Mr. QUARLES. In the Department of Commerce.

Mr. BALWAN. In the Department of Commerce?

Mr. QUARLES. The Department of Commerce Building; yes, sir.

Mr. BALWAN. Does the Air Navigation Development Board have contracting powers? I mean, do they have the power to get money and contract for the development of any system which Air Navigation Development Board might want implemented?

Mr. QUARLES. I would like to ask Colonel Taylor to answer that. It is a little bit complicated. But let's ask Colonel Taylor to answer it, sir.

Colonel TAYLOR. It is an extremely complex question, Mr. Balwan. I will do the best I can with it.

We obtain authority to buy developments from the military members, Army, Navy, Air Force, and from the Department of Commerce. In no case do we have contractual authority.

In the case of the Department of Commerce, we spend that money through Department of Commerce contracting officers.

In the case of the military, we spend these funds through military procurement officers.

We make requests upon the appropriate Departments in accordance with budget planning that they expend certain moneys in accordance with line items which are submitted on the budget.

Each military department handles its budget in accordance with its own budgeting rules.

This was not true, however, until the formation of the present Board. The old Board, let's say up until approximately the first of January of this year——

Mr. QUARLES. Last year.

Colonel TAYLOR. Last year. Excuse me. January 1954.

The old Board was budgeted for entirely by the Department of Commerce. Even so, the expenditure of moneys was done through contracting officers of the Department of Commerce under Department of Commerce contracting rules.

In no case—I am using a term now, and I hope it is understood—were their direct contracts issued by the Air Navigation Development Board. This latter is hearsay. I have only been Staff Director of the Air Navigation Board since the first of April 1954.

Mr. BALWAN. Who determined the requirements on which Commerce or Defense contracts fall for equipment?

Colonel TAYLOR. We accept our requirements through the Air Coordinating Committee's Navigation Panel, which are given to the Air Coordinating Committee by each service that has a requirement. This includes the Department of Commerce.

As you probably know, the Department of Commerce Assistant Secretary, for the moment at least, is the chairman of the Air Coordinating Committee, and Mr. Lee, Civil Aeronautics Administrator, is chairman of the executive council of the Air Coordinating Committee.

So each of these services, each using service of aviation, submits its requirements through the Nav Panel, which in turn submits them to the Air Navigation Development Board.

We, in turn, at the staff level, seek guidance from our senior Board, the Air Navigation Development Board itself, for money and program approval.

Mr. BALWAN. Who submits the budget to the Congress, the Department of Commerce?

Colonel TAYLOR. Each service.

Mr. BALWAN. Each service?

Colonel TAYLOR. Yes, sir.

Mr. BALWAN. So that the cost for the development of VOR–DME may be found in the military budgets and the Department of Commerce budgets?

Colonel TAYLOR. Not necessarily so, because we have to relate this to previous action under the old Board regime, and also I would like to mention here that VOR was in being and installed at the time of Radio Technical Commission for Aeronautics Special Committee 31. VOR at that time was a much disputed subject.

Mr. BALWAN. How much money has been authorized, appropriated, obligated, and spent? Do you have anyone here who can give us the total figures on the total investment in VOR–DME to this point?

Colonel TAYLOR. No, sir, I don't believe we are prepared to answer that question. This would take combined research by the people at Air Navigation Development Board staff, and by the CAA.

Mr. QUARLES. We will be glad to submit that information.

(Information subsequently furnished is attached.)

Answer as promised by Mr. Quarles: $117,400,000 for the VOR. This includes CAA $44,600,000 for ground omnirange and distance measuring equipment.
Other Government: $30,000,000 (this is for 26,000 VOR receivers).
Non-Government: $42,800,000.
Installation: $25,000,000.
For a total of: $117,000,000.
Mr. Holifield's statement of $117,400,000 evidently did not include the installation cost ($25,000,000), but did include total Government and non-Government expenditures.

Mr. HOLIFIELD. We have been given a figure of over $117 million.

Mr. QUARLES. For VOR–DME, including development and implementation of it, I think that checks closely with figures that we have.

Mr. HOLIFIELD. Fairly close?

Mr. QUARLES. Yes. You are speaking of the Government part of this and you are not including the part that users of the airways have spent in equipping their planes with this equipment?

Colonel TAYLOR. That's right.

Mr. HOLIFIELD. That's right. Federal airways expenses are included in this.

Mr. QUARLES. Right.

Mrs. GRIFFITHS. Mr. Chairman, may I ask a question? How much of this money came through the military budgets and how much through the Department of Commerce budgets; do you know?

Mr. QUARLES. The development of VOR–DME, I think I can say, was entirely Department of Commerce money appropriated; entirely the Department of Commerce, in the first instance, for the development of equipment and in the later instance for the purchase and installation of equipment in the Federal airways.

Mrs. GRIFFITHS. Was the military ever asked, or do you know?

Mr. QUARLES. To contribute money?

Mrs. GRIFFITHS. Yes, through their budgets.

Mr. QUARLES. I am not aware that the military was ever asked to contribute money for this purpose. This was joint planning, but it was budgeted through the Department of Commerce.

Mr. HOLIFIELD. Does this include the cost of the 28,000 sets which you have in storage?

Mr. QUARLES. No, it does not, sir. I thought we were speaking only of the development of the equipment and the installation of the ground equipment.

Mr. HOLIFIELD. I see.

Mr. QUARLES. The users of the air space have equipped themselves, and some of the users of the air space are the Military Departments, and for their use they have purchased the equipment with their own funds.

Mrs. GRIFFITHS. Yes, you didn't have to request those funds for anything. They got the money through their budgets.

Mr. QUARLES. That's right.

Mr. GARDNER. But we believe that number is included in the $117 million.

Mr. HOLIFIELD. For the 28,000 sets?

Mr. GARDNER. 26,000 sets.

Mr. HOLIFIELD. 26,000 sets?

Mr. GARDNER. Right.

Mr. HOLIFIELD. We will let Mr. Balwan's questions then stand, and you can confirm the figure that we have spoken of.

Mr. BALWAN. One of the big questions in this controversy has been insistence of certain people that the civilian aviation interests did not know throughout the development of the common system and the adoption of that system that TACAN was in existence.

Could you comment on that in any way, any more than what you have?

Mr. QUARLES. Well, I believe that when you say the civilian aviation interests, of course that is a very broad term, and it is hard to cover it with one answer.

There were certainly parts of the civilian aviation interests that did know of the development of TACAN. Only those who had reason to have classified information knew of the characteristics of TACAN and just what was being done about it, and it is certainly true, I am sure, that there were many segments of the civilian aviation industry that were not well informed about TACAN.

Mr. HOLIFIELD. Did you feel that you were justified in going ahead with a secret system and at the same time continuing to spend millions of dollars in a system such as VOR–DME?

Mr. QUARLES. I will have to answer that question, sir, in different time phases.

Mr. HOLIFIELD. In view of the fact that military people were participating in the TACAN research and development, and they were also sitting on this coordinating board in making the decision there to go ahead and install and spend appropriations for VOR–DME, while in the meantime this other system was being explored.

Mr. QUARLES. In the time period prior to the setting up of the new board, this process that you describe was going on, and it was the result of an incompatible situation between the military tactical requirements and the common system requirements which no one saw a way

to resolve, and the military people, having a real military need for tactical equipment, proceeded, it seems to me properly, although I was not a party to it, proceeded to develop for themselves and equip themselves, prepare to equip themselves with navigational equipment that they would need in tactical use.

They could not release this equipment for common use because of security, and the Civil Aeronautics people, in line with their charter, did proceed to equip the airways with the common system VOR–DME, which was available, and which was useful for the purpose, but which was incompatible with TACAN.

Mr. BALWAN. We have requested, and the Department of Defense understands that we will get a copy of both the classified and unclassified report of the VORTAC Committee.

Mr. QUARLES. Right. You have received for the record the unclassified report, and we will furnish you the classified report.

Mr. BALWAN. And the unclassified report you have submitted includes in part the findings of the consultants' report?

Mr. QUARLES. It does, because the VORTAC Committee in making their report to the Board incorporated in their report the findings and recommendations of the consultants. There is, however, a classified consultants' report which we will be glad to furnish to your committee.

Mr. HOLIFIELD. Now, as long as we have brought up the name of the VORTAC Committee, will you please tell us what that committee was, who the people were that served on it, who they represented, rather.

Mr. QUARLES. That committee was set up as an advisory committee to the Air Navigation Development Board, to be representative of all users of the air space. Its composition, sir, is given in my prepared statement, and it represented the Department of Commerce, the Air Transport Association. The Department of Commerce member on the committee was—

Colonel TAYLOR. Mr. Peter Caporale.

Mr. QUARLES. The Air Transport Association representative on the committee was Mr. Milton W. Arnold, who was also the chairman of the committee.

The Aircraft Owners and Pilots Association was represented by Mr. Karant.

Colonel TAYLOR. Mr. Max Karant.

Mr. QUARLES. The National Business Aircraft Association was represented by Mr. Cole Morrow; the Army was represented by Colonel Lloyd Wilson; the Air Force by Colonel French; the Navy by Mr. Pyle and Mr. Rothrock; and my office and the Department of Defense was represented by Mr. Ernest Wood.

Mr. HOLIFIELD. That would make a committee of eight.

Mr. QUARLES. That is right, sir.

Mr. HOLIFIELD. And their purpose was to explore this TACAN development as well as the VOR–DME?

Mr. QUARLES. That is right.

Mr. HOLIFIELD. And to make a recommendation to your Air Navigation Board?

Mr. QUARLES. Right.

Mr. HOLIFIELD. Now, did they subsequently make such a recommendation?

Mr. QUARLES. They did, sir. They rendered their report, which I have submitted, and that report includes recommendations. However, the committee split in their recommendations.

My representative, because of my own position on the Board, was a nonvoting member of the committee. That left 7 voting members, and the 7 voting members split 4 to 3 in their findings and recommendations.

Mr. HOLIFIELD. Now, was that division in the following order: Your three military representatives and the representative of the Air Transport Association voted for the TACAN procedure?

Mr. QUARLES. That's right.

Mr. HOLIFIELD. The three civilian agencies, the Civil Aeronautics people in Commerce, the National Business Aircraft Association, and the Aircraft Pilot and Owners Associations, voted against that?

Mr. QUARLES. That's right.

If I may say, sir, the Air Transport Association is, of course, also civilians. I don't want to leave the impression—

Mr. HOLIFIELD. Yes, I noted that, that they are civilians.

Mr. QUARLES. Yes.

Mr. HOLIFIELD. Now, is it true that the vote of the Air Transport Association has been questioned by some of the major airlines, such as United, Pan American, and American Air Lines, as being an unrepresentative vote of the civilian segment?

Mr. QUARLES. I can't testify to that, sir, except to say that I myself have talked to the president of Pan American and the president of Trans-World Air Line, and the opposite is true. They have endorsed this situation. I have talked to no president of an airline who opposed this.

Mr. HOLIFIELD. Has there been any formal protest entered against this recommendation to your knowledge by the United Air Lines, the Pan American Air Lines or the American Air Lines, or any other airline?

Mr. QUARLES. There have been none entered against it to my knowledge, but since this would have been entered, perhaps entered to Air Transport Asociation, I am perhaps not well qualified to speak.

Mr. HOLIFIELD. All right. Are there any of your staff here this morning that could testify further on that point?

Mr. QUARLES. I think Colonel Taylor knows pretty accurately what has been happening. Let's ask Colonel Taylor to amplify.

Colonel TAYLOR. I recall of no instance, and I am sure I would recall if it had happened, that there has been any protest informally or formally made by any airline pilots or owners or operators.

Mr. HOLIFIELD. In the major airlines?

Colonel TAYLOR. Yes, sir, major or nonscheduled. I have had no word to my knowledge from them.

Mr. HOLIFIELD. The vote then to proceed was 4 to 3, and therefore, shows a very decided split in the Board, does it not?

Mr. QUARLES. In the VORTAC Committee, sir.

Mr. HOLIFIELD. Yes. And then, of course, when it came to the vote on your Air Navigation Board, as I understand it, you testified that there was a unanimous vote?

Mr. QUARLES. That's right.

Mr. HOLIFIELD. With the three military people considered as a vote of one, or did they have separate votes?

Mr. QUARLES. Well, there was a unanimous vote, if you consider the members of the Board, each member of the Board voted for it. However, actually had there been a split, there would have only been 2 votes, 1 from Defense and 1 from Commerce, and that situation didn't arise.

Mr. HOLIFIELD. At that point, why did the Department of Commerce reverse its former stand and vote with the military?

Mr. QUARLES. I think that is a fair statement, although when you say its former stand, there had never been, this matter had never been at issue in the Board in the sense that it was at the meeting at which this course of action was adopted.

Mr. HOLIFIELD. But the CAA representative, Mr. Caporale, working on the VORTAC Committee, did vote against that?

Mr. QUARLES. That's right.

Mr. HOLIFIELD. Now, was he the same person that was represented on the Air Navigation Development Board?

Mr. QUARLES. He was not, sir. The Department of Commerce was represented by Under Secretary Murray on the Air Navigation Development Board.

Mr. HOLIFIELD. Is he his superior?

Mr. QUARLES. His superior.

Mr. HOLIFIELD. His superior reversed Mr. Caporale's former stand. Proceed, Mr. Balwan.

Mr. BALWAN. Did you say, Mr. Secretary, that we could have the report of the ad hoc group?

Mr. QUARLES. The report of the ad hoc group is classified, but I will be glad to submit it on that basis.

Mr. HOLIFIELD. In executive session?

Mr. QUARLES. In executive session.

Mr. BALWAN. Could you repeat just what the ad hoc group did and when it came into the picture?

Mr. QUARLES. The ad hoc group came into the picture when the Air Navigation Development Board received a report from the VORTAC Committee, which was split.

This left us a split position to consider, and the Board felt that it was not at that time ready to adopt either of the views that had been considered by the VORTAC Committee, and that instead the Board should consider the best third alternative that could be concocted at that time, so the ad hoc group was set up of experts to devise the best third alternative system for standardization at that time, and the report of the ad hoc group presented such an alternative system and priced it out in terms of dollars and time.

Mr. BALWAN. I am thinking of the question of how problems are resolved in going from development into production at the level of the Office of the Secretary of Defense, does the Assistant Secretary for Flight Engineering—is that what you call that?——

Mr. QUARLES. Application engineering.

Mr. BALWAN. Application engineering. Has he anything to do with this VOR-DME controversy?

Mr. QUARLES. He has entered into this navigational aid situation, and it will come out in Mr. Fogler's testimony that, as a result of application of engineering considerations in this matter with the services, the procurement of this kind of equipment was substantially modified. I think you will find that Mr. Fogler will cover that.

Mr. BALWAN. You relate it in your statement that one of the decisions or one of the points in the Board's decision was to close down DME, is that right?

Mr. QUARLES. That's right. To close it down, or more precisely, to say that operation of it would not be guaranteed after June 30, 1955.

Mr. BALWAN. After this coming June?

Mr. QUARLES. This coming June.

Mr. BALWAN. There would be no incentive then for any aircraft owners to buy DME equipment?

Mr. QUARLES. There would not be, I should say, and in fact, that was the deliberate purpose of that group.

Mr. BALWAN. What do we have in its place?

Mr. QUARLES. TACAN is a combination of azimuth measuring equipment and distance measuring equipment in exactly the same sense that VOR–DME is that combination, and TACAN will supply distance measuring equipment as part of the TACAN system.

Mr. BALWAN. Has that aspect of TACAN been developed to the reliability that DME was?

Mr. QUARLES. It has not been as of this date.

Mr. BALWAN. So that for some time until TACAN is developed, there will not be available distance measuring equipment?

Mr. QUARLES. That is correct, if we pursue the course that now appears to be the likely course, and I answer it that way because we are leaving the ground DME equipment installed and in readiness to be turned on again when and if it appears we can turn it on and not prevent the standardization of TACAN, on the one hand, or that we can turn it on for a useful period of time until TACAN becomes available.

But this is a decision, as I attempted to explain, that needs to have some of these problems resolved before one can wisely decide just how long the civil DME could be left turned on without preventing a proper solution of this whole problem.

Mr. HOLIFIELD. You have given us the number of these stations which run over 436, I believe.

Mr. QUARLES. For VOR.

Mr. HOLIFIELD. For VOR, and 241 for DME, that are in operation at this time.

Would it not have been possible for you to have continued research and development in certain areas and allowed this system to continue to work for the benefit of the people who are using it until you have developed this TACAN to the point of practical operability?

Mr. QUARLES. This would have been possible, yes, sir. The Board weighed that matter very carefully and reached the conclusion that it would not be wise in the public interest to do so, and the reason it reached that conclusion is the following:

If you allowed DME to continue in use, there would be additional purchasers of DME equipment, depending on it, and in a period of time you would have created a situation where DME service was so important in the public interest that you would have been blocked from implementation of TACAN, which needs the same frequency space.

So it was the opinion of the Board that the best public interest would be served by discontinuing the use of DME at least until such

time as we could be sure that its continued use would not block the standardization of TACAN.

Mr. HOLIFIELD. How practical is TACAN development at this time? To what degree of accuracy can it now be operated?

Mr. QUARLES. The TACAN equipment produces the accuracy stated by the consultants, that is the one degree azimuth accuracy which is required for military purposes and which compares with three degrees azimuth accuracy for the VOR azimuth.

The distance measuring equipment of TACAN is substantially as accurate as the DME. They are standoff equipments. The trouble with TACAN today isn't the design of the equipment. Some little design matters have been ironed out in this year in which the consultants have been working with the contractors, but there is a further period of improving the reliability in making the equipment as sound as it should be when and if it is installed in the Federal airway and installed in commercial airplanes for this important navigation function.

Mr. HOLIFIELD. Now, then, you state to this committee that it has reached a degree of accuracy to the point of 1 degree, and that you can rely on that.

Mr. QUARLES. Can rely on the accuracy of the design, sir, but I don't state that the equipment has been perfected in manufacture to the point where it is a reliable equipment. That will take further time.

Mr. HOLIFIELD. Does your remark pertain to land operation or to carrier operation?

Mr. QUARLES. It pertains to both, sir.

Mr. HOLIFIELD. You are stating to the committee then that in landing on aircraft carriers you have now obtained the 1 degree of accuracy in the operation of this instrument?

Mr. QUARLES. That is correct, if you will allow me again to state that I do not claim it is perfected in its reliability as equipment as of this moment.

Mr. HOLIFIELD. What was your experience in the tests as to reliability?

Mr. QUARLES. I can't answer that question, sir, in detail. That will be answered in the consultants' report which we will file with your committee.

In general terms, it was that the equipment was not as reliable in its present state as the VOR–DME equipment, but if particular equipments were properly conditioned and handled, it delivered the service that it was intended to deliver.

Mr. HOLIFIELD. What status are you in now in regard to the manufacture of these sets? Are you in the stage of research and development, or have you given procurement production contracts?

Mr. QUARLES. The Navy has given production contracts, and then in the light of these findings, has held back in the actual production. Mr. Fogler will cover that in detail. If you are not satisfied, I will be glad to answer any questions.

Mr. LIPSCOMB. Mr. Chairman.

Mr. HOLIFIELD. Go head, Mr. Lipscomb.

Mr. LIPSCOMB. Can TACAN use the ground installation stations of DME, the 241?

Mr. QUARLES. TACAN cannot use the DME ground equipments as such, but TACAN can be sited on the sites of the present VOR–

DME stations. Now perhaps I haven't answered your question, Mr. Lipscomb.

Mr. LIPSCOMB. When you turn on or cut off, rather, DME on June 30, will there be new ground installations necessary to turn on TACAN?

Mr. QUARLES. There will have to be new ground installations. It is separate ground equipment.

Mr. LIPSCOMB. As of July 1 then what do you intend to start doing as far as ground installations for TACAN?

Mr. QUARLES. The military will start the installation of TACAN ground equipments on continental sites and on carriers. In the present year there will be some equipments, so we are starting this installation.

However, it will be some time before the Federal airways have TACAN ground equipment, and during that period the Federal airways will depend on the VOR azimuth equipment which will be left in operation for the next 10 years at least, but will not have during this interim period, will not have distance measuring equipment.

Mr. LIPSCOMB. How much do you intend to invest in ground installations before the reliability of TACAN is determined?

Mr. QUARLES. May I wait until Mr. Fogler presents his information and see if you then have a question on that, Mr. Lipscomb?

Mr. LIPSCOMB. Maybe this one would go to him, too. How are you budgeting now your installations for TACAN? Are you going to use DME money?

Mr. QUARLES. No. The only installations for TACAN that are now being budgeted are strictly military installations.

There is no present determination to install TACAN in the Federal airways and there have been no funds requested for the installation of TACAN in the Federal airways as part of the CAA system.

Mr. HOLIFIELD. Any further questions? Mr. Kilgore?

Mr. KILGORE. Mr. Secretary, this may be a question which you heard somebody else ask. See if I understand correctly on the general statement as to the development phase of TACAN.

Would it be a proper analysis to say that insofar as its operation under optimum conditions are concerned, that you are satisfied with it, but the matters of packaging, of resistance to vibration and temperature changes and that sort of thing, manufacture, are the problems that yet have to be solved?

Mr. QUARLES. That is correct.

Mr. HOLIFIELD. Is that all, Mr. Kilgore?

Mr. KILGORE. That is all.

Mrs. GRIFFITHS. Mr. Chairman, may I ask a question?

Mr. HOLIFIELD. Mrs. Griffiths.

Mrs. GRIFFITHS. I would like to ask you, Mr. Secretary, are civilian users of the air less safe in the air without DME than they would be if they had it?

Mr. QUARLES. We believe that DME will be a useful navigational device for all users of the airspace.

However, this is the opinion of, for example, the Air Transport people, the commercial airlines people, has been that the DME function isn't nearly as important as other things in affecting the safety of the airways.

DME enables, would enable, users of the Federal airways to use the airways in greater traffic density, and it would have some other advantages, and it does increase the pilot's knowledge under overcast conditions of his precise position in space, but it has not been considered to be an important element of air traffic and navigational aids up to this time.

Mr. HOLIFIELD. I can't understand that; if you will allow me to interrupt, I can't understand you saying that an aid to knowing where you are in space isn't important when you are approaching a runway, for instance.

Mr. QUARLES. This, Mr. Chairman, isn't a runway-approach aid as applied to the Federal airways in that the final approach stage there are other navigational aids that come into play.

But in the navigation of the airways it is a useful device. The amount of its usefulness, the importance of its usefulness, is reflected by the fact that the Air Transport Association and the commercial airlines had not thought it necessary to purchase and install this equipment in their airliners, even though the ground equipment was being installed.

Mrs. GRIFFITHS. That though is because they knew or had heard that it was about to be outmoded. That was a problem. I mean they didn't want their equipment obsoleted, isn't that right?

Mr. QUARLES. I think that was surely a factor. You are very right there, Mrs. Griffiths.

I think it is also true, however, that in voting for the TACAN plan, they specifically stated that they considered the DME not a serious sacrifice under present conditions.

Mrs. GRIFFITHS. Who stated that?

Mr. QUARLES. It was stated to us by the executive vice president of the Air Transport Association, but it has also been stated to me by those airline executives with whom I have talked about it.

Mrs. GRIFFITHS. As serious financial sacrifice?

Mr. QUARLES. No, I didn't mean to say that. I wasn't addressing myself to the financing aspect of it at all. Serious sacrifice in air safety and in air ability to operate the civil airways, operate on the airways.

Mrs. GRIFFITHS. How many civil users are there of the air annually, or do you know?

Mr. QUARLES. I can't answer that. Do you mean different planes that at one time or another fly the air?

Mrs. GRIFFITHS. Well, how many commercial passengers are carried annually, would you have any idea?

Mr. QUARLES. I would be guessing at that, Mrs. Griffiths. If I may, I would like to answer that for the record later because I don't know that exactly.

(Answer submitted subsequent to hearings:)

For the record: The Statistical Handbook for Civil Aviation for 1954, published by the United States Department of Commerce, shows that the domestic airlines, including trunk local service, helicopter and territorial carriers, carried a total of revenue passengers of 32,343,867.

Mrs. GRIFFITHS. Well, is it possible that over a 10-year period of time that all civilian users of the air are going to be subjected to an additional risk safetywise in order to have a 10-year period in which to develop something, according to your report, I believe may never be developed?

Mr. QUARLES. The answer to that, Mrs. Griffiths, is that we feel we are following the course of maximum advantage to the users of the civil airways, and that was the whole purpose of our decision.

I have to agree that it involves some temporary disruption of the plan, but we believe not a serious one, and we believe over the 10-year period that we are working in the interests of the users of the airways and not against the interests of the users of the airways.

Mrs. GRIFFITHS. In the original committee—and I would like to know is that committee set up by statute or is that just the Air Navigation Board appointed a committee?

Mr. QUARLES. The Air Navigation Board is a creation of the Department of Defense, and the Department of Commerce, and is not set up by statute.

Mrs. GRIFFITHS. So that the VORTAC Committee was not set up by statute?

Mr. QUARLES. The VORTAC Commitee was not set up by statute.

Mrs. GRIFFITHS. In the original committee, VORTAC Committee, how many civilian users were there?

Mr. QUARLES. The VORTAC Committee— when you say "original" I am not quite sure I understand you. There was never but the one committee.

Mrs. GRIFFITHS. The first group that decided upon VOR–DME as the common system.

Mr. QUARLES. There was no VORTAC Committee at that time, and that goes way back of my connection with them. I can't answer that question. I will be glad to attempt to get the answer for you.

Mrs. GRIFFITHS. How long ago was the VOR–DME decision made?

Mr. QUARLES. The VOR–DME decision to install this equipment on the Federal airways was made, of course, by the Civil Aeronautics Authority, CAA, with congressional approval. Can you state the date of that?

Mr. GARDNER. The military date was May 12, 1948, for the military decision to use VOR.

Mr. HOLIFIELD. Our information is that the Air Navigation Development Board developed the criteria and specification for common system of air navigation over a period of years from 1947 to the present time, and it was this Board that agreed to and developed the VOR–DME device.

Mr. QUARLES. That is correct, sir, and the Board developed the device. The decision to install the device on the civil or Federal airways was a Civil Aeronautics Authority decision.

That decision must have been taken around 1948 or 1949, but I will have to correct the record to be exact about that.

(Submitted subsequent to hearings:)

In response to Mr. Holifield's question, Mr. Quarles is endeavoring to establish the date of the decision to install VOR and DME on the Federal Airways. He asked that he be permitted to change the record to give the exact dates.

The dates are: Inclusion of VOR in CAA budget was first made in fiscal year 1946. Inclusion of DME in CAA budget was first made in fiscal year 1948.

Mrs. GRIFFITHS. Now, I would like to ask you one other question and that is all. Actually the air, which is a great natural resource, has been abandoned by Congress to this voluntary committee set up by Defense and the Commerce Department, is that right?

Mr. QUARLES. Mrs. Griffiths, when you ask me whether Congress has abandoned the air, you realize I would be speaking from hearsay there. I can only say that Congress has supported all of our requests for funds to implement these plans, and it has seemed to me to be exceedingly aware of the needs of the users of the airspace and exceedingly anxious to promote the welfare of the users of the airspace, so I have no information that would make me feel that they have abandoned it.

Mrs. GRIFFITHS. But they are not controlling the Board. The Board is not their statutory child.

Mr. QUARLES. The Board is not their statutory child, but they, of course, do appropriate the funds to the Board, and the Board would be without any ability to proceed without funds, so I think it is fair to say that the Congress is aware of the program of the Board, and annually reviews these programs and uses its discretion in the funds they appropriate.

Mrs. GRIFFITHS. That is all.

Mr. HOLIFIELD. Mr. Fascell?

Mr. FASCELL. No questions.

Mr. HOLIFIELD. Mr. Garmatz?

Mr. GARMATZ. No questions.

Mr. HOLIFIELD. Mr. Dawson? Mr. Hoffman?

Mr. HOFFMAN. Did I understand you to say in substance that VOR gave you sight?

Mr. QUARLES. It gives you direction, sir, from a reference station.

Mr. HOFFMAN. And DME gave you distance?

Mr. QUARLES. Gives you distance from the station, yes, sir.

Mr. HOFFMAN. And TACAN tries to do the same thing?

Mr. QUARLES. TACAN does both things in a somewhat different way.

Mr. HOFFMAN. That is all.

Mr. LIPSCOMB. Mr. Chairman.

Mr. HOLIFIELD. Mr. Lipscomb.

Mr. LIPSCOMB. When TACAN finally goes into operation, VOR and DME both will be replaced. It will supplant both of those, is that right?

Mr. QUARLES. If TACAN is standardized for the common system use, when it is completely installed, it will perform both the functions of VOR and DME, and while the VOR equipment will be continued in service until 1965 for those users who have it installed and do not have TACAN installed, TACAN functionally will replace both.

Mr. LIPSCOMB. Do you know what the VOR costs an instrument?

Mr. QUARLES. The airborne installation of VOR?

Colonel TAYLOR. There are several different types of equipments. There are some equipments that are manufactured for private pilots which can be obtained for, I believe it will run $500. The more fungus-proofed, arctic-proofed, high-altitude type of equipments run considerably more than that, $2,500 to $3,000.

Mr. LIPSCOMB. And how much does DME run?

Colonel TAYLOR. DME I believe—I would like to be able to correct the record later on this—I believe they sell for $3,500.

(Submitted subsequent to hearings.)

Mr. James Riddle, president of NARCO Corporation, a manufacturer of distance measuring equipment airborne sets, testified on Friday, March 11, that the NARCO list price was $5,000. His testimony was given before the Trans-

portation Subcommittee of the House Interstate and Foreign Commerce Committee.

Mr. LIPSCOMB. The DME is the most expensive portion of this VOR–DME system?

Colonel TAYLOR. Yes.

Mr. QUARLES. Airborne.

Mr. HOLIFIELD. Mr. Fascell?

Mr. FASCELL. Mr. Secretary, do I understand that the development of TACAN is based primarily on a military need that became apparent with the use of VOR–DME?

Mr. QUARLES. It became apparent, sir, before VOR–DME.

The development of TACAN was started in 1947, before there was an Air Navigation Development Board and before there was a VOR–DME, but the tactical requirements for such a system were apparent after World War II, and the development was started shortly after World War II.

Mr. FASCELL. I see. Well, do you have any information within your knowledge at the time in 1948 that decision was made to adopt for military and civilian purposes. VOR–DME, what military representation was made with respect to the use of VOR–DME for military purposes?

Mr. QUARLES. There were military representatives on the Air Navigation Development Board who participated in the final development of this equipment, and the determination to install the equipment on the civil airways was an entirely civil Aeronautics decision. That was not a military decision.

However, I don't imply that the military disagrees with it. I merely don't want to imply that they were a party in it.

Mr. FASCELL. Just one more question occurs to me.

Are there any reports, consultative or otherwise which now exist, which show at the time of the final decision on VOR–DME the deficiencies, if any, that it would have with respect to military application?

Mr. QUARLES. Among others, and I have no doubt there are others, but the last and most authoritative one is the report of the consultants, this consultant group that was set up to be advisory to this VORTAC Committee.

Mr. FASCELL. Well, that is the latest group?

Mr. QUARLES. That's right, sir, and that report which is classified will be filed with your committee.

Mr. FASCELL. Yes, sir. Well, now, that is not what I had in mind. I am going back now to 1948 or 1947 when the first decision was made. As there any reports with respect to military applications made at that time as to VOR–DME?

Mr. QUARLES. I can't speak to reports, but I believe I can answer your question, if I may try.

Mr. FASCELL. All right, sir.

Mr. QUARLES. The VOR equipment operates at around 100 megacycles, which is fairly low frequency and requires a fairly large antenna and a fairly large clear space of ground like 1,000 feet of radius of cleared space of ground in order to be effective.

Now the people that were having to navigate planes to and from carriers knew that they didn't have any such amount of cleared ground and cleared space for the antenna system you need for the VOR

equipment, so from the very start it was apparent to the experts that VOR was not a carrier navigation equipment.

The Navy then, which had, I understand, to develop attack and equipment at about 10 times the frequency range of the VOR equipment, saw that VOR would not meet their requirements and felt that they must continue to develop their tactical equipment.

Now you asked were there reports showing this, and I say that it would be common knowledge among experts that this is a fact.

Mr. FASCELL. I think that answers exactly what I wanted to know.

Mr. HOLIFIELD. Mr. Hoffman.

Mr. HOFFMAN. What is there on an airborne craft that tells whether you have neighbors?

Mr. QUARLES. The particular equipment that we are talking about gives no information about neighboring aircraft.

Mr. HOLIFIELD. Is there any other equipment that gives that information?

Mr. QUARLES. There are no other equipments now being planned that will tell one pilot of the neighborhood of another pilot, but all of these equipments in enabling the ground-control operator, ground controller to know where all the planes are, can telephone to planes and tell them if they are unsafely close to each other, and that kind of thing. But this does not give one plane directly information as to the neighborhood of another plane.

Mr. HOFFMAN. Thank you.

Mr. QUARLES. Mr. Eckhart.

Mr. ECKHART. Mr. Secretary, at the time the technical consultants reported to the VORTAC Committee, was the TACAN equipment in production?

Mr. QUARLES. I missed one word there, sir.

Mr. ECKHART. At the time the technical consultants made their report to the VORTAC Committee, was the TACAN set in production?

Mr. QUARLES. Production orders had been placed prior to that time, and some amount of production was continuing.

Mr. ECKHART. And did the technical consultants have available to it any of the test results that may have been made either on the prototypes or on production models?

Mr. QUARLES. Yes, they did, sir.

Mr. ECKHART. In what types of reports was that information?

Mr. QUARLES. Well, may I ask Colonel Taylor to respond there? There has been an evaluation contract let to a commercial concern to evaluate TACAN, and the reports of that evaluation contract were available at this time. Will you amplify that, Colonel Taylor?

Colonel TAYLOR. Yes, sir. That firm was Melpar, in Alexandria, here. In addition to that, there were test results made available to the consultants from flights made at the technical division evaluation center, Indianapolis, under a CAA operation.

Additionally there were reports done by the reliability group in Applications Engineering, Pentagon, which is a Department of Defense organization, and flight tests that had to do with the manufacture of flight tests which I believe were conducted for the most part from Nutley, N. J., and these were in addition to the tests the consultants did themselves at Nutley, N. J., site.

We can, if requested, furnish a classified report concerning the Caldwell, N. J., sites or we can furnish the unclassified version. There may be other reports.

What I am trying to establish is that as far as it is known, all reports that had ever been made regarding TACAN accuracy or reliability were made available to the consultants. There was nothing held back from any of the services, to my knowledge.

Mr. ECKHART. Do you know, Colonel Taylor, whether or not WADC or air proving grounds had any of this equipment available for testing purposes?

Colonel TAYLOR. Air proving grounds had and still have equipment that they are working with continuously.

Mr. ECKHART. Do you know whether or not WADC has rendered any written reports on the operational suitability of the TACAN equipment?

Colonel TAYLOR. I would to refer that question to General Blake, who is well qualified on this subject.

Mr. QUARLES. General Blake, for the record, is the Chief of Communications of the Air Force.

General BLAKE. It is my understanding all of the WADC, Mr. Chairman, was available to the consultants. That can be confirmed by the consultants themselves, however.

Mr. ECKHART. Mr. Chairman, could we ask at this time for some of the better reports, let's say, the more complete reports that were made available to the technical consultants on this equipment?

Mr. HOLIFIELD. Can you furnish us those reports?

Mr. QUARLES. I would like to suggest this response there: That we furnish you with the consultant's reports which will in turn refer to their source material, then we will furnish you any additional material you would like us to furnish.

Mr. HOLIFIELD. I think that will be satisfactory.

Mr. ECKHART. Mr. Chairman, just one additional question. Are you prepared to discuss, Dr. Quarles, approximately what the total investment of the Department of Defense is at the present time in TACAN equipment?

Mr. QUARLES. Mr. Fogler will bring that out in his statement, and we will amplify that if you need further information.

Mr. HOLIFIELD. Mr. Balwan.

Mr. BALWAN. To follow up Mr. Lipscomb's question about cost, is it anticipated that TACAN will be less expensive than or more expensive than the currently commercially produced VOR-DME combined?

Mr. QUARLES. The general answer to that question is that a TACAN equipment complete is expected to be about the same cost as a complete VOR–DME installation in a plane. We are talking now about the high-grade DME equipment that Coloney Taylor referred to.

Mr. BALWAN. From the point of view of manning ground stations, are ground stations manned for VOR–DME?

Mr. QUARLES. Are they at this minute manned?

Mr. HOLIFIELD. Is it necessary?

Mr. BALWAN. Is it necessary that they be manned, that they have constant personnel around a station?

Mr. QUARLES. In a literal sense, no; although they require such attendance that would provide for maintenance and that kind of thing. They are unattended stations except for maintenance.

Mr. BALWAN. Is it anticipated that the same conditions would be required for TACAN ground stations?

Mr. QUARLES. That's right.

Mr. BALWAN. That they will not have to be manned any more than the VOR–DME stations are manned?

Mr. QUARLES. That is a fair statement.

Mr. HOLIFIELD. Mr. Hoffman.

Mr. HOFFMAN. You are familiar with the fact that the Congress has endeavored to get a common system. For instance, I find this in yesterday's record:

> The common system grew out of recommendations made by a subcommittee of the Interstate and Foreign Commerce Committee in the 80th Congress, of which the gentleman from California, Mr. Hinshaw, was chairman. That subcommittee in House Report No. 885 of the 80th Congress urged the establishment of a single system which will safely and economically serve the requirements of both commerce and national defense simultaneously.

Is that what you are trying to do now?

Mr. QUARLES. It is, sir, and we are familiar with Report 885 that you speak of. There were two other reports also of the 80th Congress which were also prepared by the Interstate and Foreign Commerce Committee of the Congress, of the House. These were Nos. 885 and 1065, as well as 59 which you mentioned.

Mr. HOFFMAN. Now I find in the record of yesterday that the chairman of the Interstate and Foreign Commerce Committee says:

> The committee questioned the Administrator of Civil Aeronautics about this on February 11 in open session. Because details of the TACAN system are classified, it was decided to postpone an investigation until an executive session could be held on next Thursday morning.

That would be the day after tomorrow.

> The subcommittee will hear Dr. Donald A. Quarles and others.

Is that the same thing that we are talking about?

Mr. HOLIFIELD. We don't know what their interest is.

Mr. HOFFMAN. I am asking for information. I am not at all critical.

Mr. HOLIFIELD. I know. I said we don't know what the Interstate and Foreign Commerce Committee's interest is. Our interest is in following up previous hearings which we have had on the procurement, particularly in the procurement of items which have not yet been proven to be operable, letting production contracts where they are still in the research and development stage.

We are following on our ARC 21 investigation of last year, this is another item which appears to be handled the same way as the other items of last year.

Mr. HOFFMAN. But it requires a program where they are buying something before they know whether it is any good. Not any good but——

Mr. HOLIFIELD. That is one of the purposes of our investigation, to find out if this new item is a better item than the one that they have already spent $117 million on, and they are going to junk.

Mr. HOFFMAN. Is that VOR–DME?

Mr. HOLIFIELD. VOR–DME. Is that all?

Mr. HOFFMAN. That is all. I just wondered.

Mr. FASCELL. I would like to ask another question, Mr. Secretary. We say that the deficiency of VOR–DME for military application was rather common knowledge dating back to 1947, roughly speaking.

Mr. QUARLES. 1947 or 1948.

Mr. FASCELL. 1947 or 1948.

Mr. QUARLES. Yes.

Mr. FASCELL. Now being specific as to the deficiency, I have one today, and that is the application to Navy aircraft carriers. Is there any other military deficiency of VOR–DME?

Mr. QUARLES. Yes, sir, there are two. One other is that the military need for an equipment that could be readily installed on a land location is not met by VOR because we cannot be sure of having a cleared site of 1,000 feet radius with all of the requirements of the VOR system, so that the necessity for tactical siting is not met by VOR, and the third deficiency is that VOR has an inherent accuracy limitation of 3 degrees, which is not good enough for carrier operation of airplanes against enemy airplanes, and it is not good enough for the land operation of interceptors against enemy airplanes.

So the 3-degree accuracy of VOR does not meet the military requirements, and VOR fails to meet the military requirements for siting on carriers and it fails to meet the military requirement for a tactical equipment that can be sited in a practical way in tactical circumstances.

Mr. FASCELL. Now all of these matters, as I understand it, and I am reemphasizing this for clarity, were known for a good many years. This is not something that just developed in the last, this deficiency.

Mr. QUARLES. They were known with increasing firmness as the years went on. That is, we didn't, for example, know this 3-degree thing too accurately, but we did know that it wasn't calculated to give us the accuracy we needed.

Mr. FASCELL. Was there any consideration during deliberations on this matter to the determination of a report which would state that it perhaps might not be for the best interests for a unified system, and that because of the specific military needs, it might be best to develop a specific military system as apart from the then existing civil system?

Mr. QUARLES. Sir, there was an interruption that made me not quite sure I got all of your question, and it is important and I would like to be sure I answer it correctly.

Mr. FASCELL. My question is, has there been any consideration in the deliberations that have been held by your Board or affiliates to the proposition that perhaps the theory of a unified system expressed back in 1948 in these committee reports would not be to the best interests of the public or of the military, and that it would be perhaps better because of the specific needs of the military to develop a special system for the military?

Mr. QUARLES. There was such a growing feeling in some quarters back before 1949 or 1950, a feeling that perhaps one could separate the Federal airways from the tactical situation and assume they would always be different places, and we wouldn't have to have tactical planes flying and using the continental Federal airways.

However, as soon as the events of 1949 with the first Russian atomic experiments and the events of the Korean hostilities unfolded, it was apparent that the continental United States where our Federal airways are might itself be the battleground, and therefore our planes would have to operate tactically in the same place that airplanes would have to fly the Federal airways.

And at that time it became apparent that you could not compromise this thing, that you had to have a common system of air navigation of these airways that tactical planes could use as well as civil planes.

Mr. FASCELL. And that that system would have to be developed to the highest tactical needs?

Mr. QUARLES. Right.

Mr. FASCELL. That is all.

Mr. HOLIFIELD. Mr. Balwan.

Mr. BALWAN. But the differences between VOR–DME and TACAN are primarily in the extra degrees of accuracy in azimuth information and in its mobility for placing on carriers.

Mr. QUARLES. Ability to place the antenna on a carrier.

Mr. BALWAN. This calls for a kind of imposition of military considerations upon previously decided commercial approved equipment.

Mr. QUARLES. It means that there are tactical requirements over and above the Federal airway requirements if I am paraphrasing your question, Mr. Balwan.

Mr. BALWAN. Were any attempts made to modify the commercially available VOR–DME to make it suitable for the military requirements?

Mr. QUARLES. Studies were made to see if this could be done and experiments were conducted to see if it was practical, but you are up against the laws of nature here in dealing with the frequency as low as 100 megacycles, you have to have a big antenna system to do the job.

So it just seemed impractical to work at that frequency off of a carrier, for example, so we went to the thousand-megacycle range instead.

Mr. BALWAN. Was there any attempt made to develop VOR equipment in the higher frequency range such as TACAN?

Mr. QUARLES. Well, the answer to that is that TACAN itself is VOR equipment at the higher frequency range.

Mr. BALWAN. It is not merely a modification of it?

Mr. QUARLES. It is not. It is a separate system, but it performs the same function as VOR does at the higher frequency range.

Mr. BALWAN. The record is that the Navy, while it was developing TACAN, was also trying to find out how they could modify VOR–DME.

Mr. QUARLES. The Navy did pursue the VOR possibility until it had to reject it as well as developing TACAN.

Mr. BALWAN. You said that TACAN was being developed before VOR came into the picture.

Mr. QUARLES. That is right, sir, and I didn't think my last statement was in conflict with that. I will repeat it though to be sure I am not misleading you.

The Navy started the development of TACAN in 1947. It did in the course of that development also consider the possibility of adapting VOR to naval purposes and had to reject that possibility, and it did continue through that period and did complete the development of TACAN to the present time.

Mr. BALWAN. Mr. Chairman, that wasn't a trick question. I just didn't understand the development of this thing, and I think we ought to have clear for the record the Defense Department position concerning the Navy Department's trying to modify this setup.

Mr. QUARLES. Have I been responsive, Mr. Balwan?

Mr. HOLIFIELD. Yes, you have.

Mrs. GRIFFITHS. Now, is there a third system also under consideration?

Mr. QUARLES. There is a third system that will be developed as an insurance against the possibility that TACAN will not prove to be satisfactory, and that possibility arises from the fact that TACAN is in a frequency band that is limited.

And should we later find that there is not enough frequency space there, we will go to this alternative system which has the azimuth system in a higher frequency band.

Mrs. GRIFFITHS. And does not use the band VOR–DME uses, is that right?

Mr. QUARLES. That is correct.

Mrs. GRIFFITHS. So that the third system of VOR–DME could be used right now if they were both available.

Mr. QUARLES. If they were available. Now I answered a bit hastily there because a third system incorporates the present DME and would use it.

Mr. HOLIFIELD. There is one question I wanted to ask you, Mr. Quarles.

You have testified as to the accuracy of this new system of TACAN and the testimony has also been that the Navy has had the primary interest in developing it because of the need to use it on a carrier.

Now, do you want your testimony to stand that it is within 1 degree of accuracy when used on the pitching deck of a carrier?

Mr. QUARLES. I do not want the testimony to stand that the accuracy under all conditions will be 1 degree. The accuracy as determined by the consultants using test installations which were not on the pitching deck of a carrier, established better than 1 degree accuracy.

However, there would be conditions on a carrier where the accuracy might well we less than 1 degree in certain locations of a plane, and there has not been a sufficient series of tests to establish this exactly.

Mr. HOLIFIELD. Would you not be faced with a completely different situation with the oscillating motion of a carrier deck in making the tests than you would be on a stable land installed antenna?

Mr. QUARLES. We are faced with different conditions, and those tests have been made and those tests do establish approximately 1 degree accuracy under normal carrier operating conditions, but I can't give you precisely the range of azimuth errors that were encountered under all carrier conditions. I will be glad to submit a report showing that, but I can't give you that offhand.

Mr. HOLIFIELD. You may have technical men. Mr. Fogler, maybe in his testimony, might touch on that.

Mr. QUARLES. I think perhaps Mr. Fogler hasn't planned to do that, but we could very probably, if you are planning to have a session this afternoon, be prepared to give more specific detailed answers to your last question.

Mr. HOLIFIELD. We would like to come back into session at 2 o'clock this afternoon, if it is convenient for you.

Mr. QUARLES. Right, Mr. Chairman.

Mr. LIPSCOMB. Mr. Chairman.

Mr. HOLIFIELD. Mr. Lipscomb.

Mr. LIPSCOMB. Mr. Secretary, is TACAN considered a secret military instrument?

Mr. QUARLES. TACAN has up until now been classified as either secret or confidential. We are now in the process of declassifying TACAN so it may be used in the common system.

Mr. LIPSCOMB. And when this goes on commercial airlines, that fly to foreign countries, it won't matter if it falls into the hands of any potential enemy then?

Mr. QUARLES. We are facing that eventuality and declassifying it in spite of that possibility.

That, however, has in the past been precisely the reason that we were not willing to handle the TACAN development on an unclassified basis.

Mr. LIPSCOMB. Will it be some time before the military agree to release this to the commercial airlines for use?

Mr. QUARLES. No. It will be only a short time before it is declassified, and as soon as it is declassified, it will be entirely available to any user.

Mrs. GRIFFITHS. As soon as it is usable?

Mr. QUARLES. As soon as it is usable and as soon, of course, as it is installed on the airways.

Mr. HOLIFIELD. Mr. Secretary, has a similar system to VOR–DME been installed overseas to your knowledge?

Mr. QUARLES. There are competitive systems, a so-called Decca system of navigation that has been promoted overseas. However, there is also an international agreement for the use of the VOR–DME system in civil airways, and there are also agreements between this country and our allies, particularly Canada, the United Kingdom, and our NATO allies for the use of TACAN by them in tactical situations, so on both sides of this argument we have international complications.

Mr. HOLIFIELD. You have international agreements and international complications?

Mr. QUARLES. Well, I didn't distinguish between those two. There are international agreements which constitute complications when you try to do something about it.

Mr. HOLIFIELD. Has international problems had any effect upon your decisions—I don't want to use the word to "junk" but to discard the VOR–DME system and adopte the TACAN system.

Mr. QUARLES. We weighed the international problem on both sides of this argument, and as I have said, we tried to reach the overall best solution of the problem in the face of those iternational situations.

Mr. HOLIFIELD. Are there any further questions from members of the committee or the staff of Dr. Quarles?

If not, we will stand adjourned until 2 o'clock, and at that time we would like to have Assistant Secretary of the Navy, Mr. Fogler, present to testify. Thank you, Mr. Quarles.

(Whereupon, at 12 noon, a recess was taken until 2 p. m., the same day.)

AFTERNOON SESSION

Mr. HOLIFIELD. The committee will be in order.

At this time the subcommittee expresses appreciation for having Assistant Secretary of the Navy, Raymond H. Fogler, present. Mr. Fogler, do you have a prepared statement?

Mr. FOGLER. I have a brief statement, yes, Mr. Chairman.
Mr. HOLIFIELD. You may proceed.

STATEMENT OF RAYMOND H. FOGLER, ASSISTANT SECRETARY OF THE NAVY

Mr. FOGLER. I think it is only fair for me to state that in connection with what Secretary Quarles said this morning about my answering questions, that I am here somewhat under false colors. Most of the questions that he stated I could answer, I cannot personally answer, but I hope we have here individuals who can.

Mr. HOLIFIELD. All right.

Mr. FOGLER. Secretary Smith, who is in the Navy, the assistant secretary in charge of research and development, is close to this question of air navigation matters and is unable to be here. He regretted very much that he could not change his schedule in order to get here. He would like to be here. I can brief this, I think, and possibly give the individuals who can answer questions to you, to answer more questions.

I can simply tell you we appreciate the opportunity to be here. There are just 1 or 2 sentences that I would like to read.

It is my understanding that the initial intent of the TACAN program was to develop tactical air navigation equipment. Our initial objective was a tactical air navigation equipment which would be superior to any then available and more specifically such a system was required to meet acceptable performance standards for fleet operational use, to meet the operational requirement of the United States Air Force, and to provide maximum reliability and accuracy.

As the system proceeded through the usual research and development stages, the desirability of a common system became increasingly important. The Navy Department has desired and still does desire to cooperate wholeheartedly in the development of a system.

Because of the shortness of time which has been available to us for preparation, I believe it will probably be quite possible that there will be information which we will have to get for you after this hearing this afternoon and I can assure you that we will get for you anything that we do not have available here, and will do it just as promptly as possible.

Commander Laub, of the Bureau of Aeronautics, is here to outline for the chronologically the steps in the development of the TACAN system. He has worked closely with the system through its development and is regarded as the best informed officer we have in connection with the system. He has been designated by the Chief of the Bureau of Aeronautics to represent him during these hearings and to assist in every possible way. It was mentioned previously that there are some parts of the TACAN system which are still classified but in Commander Laub's presentation, it will be entirely open and possibly questions will come up which will have to be referred to the committee in executive session.

Commander Laub is head of the electronics production branch of the Bureau of Aeronautics and he is, I think—and if this isn't right I hope he will correct me—he is a carrier pilot, so he has some real experience.

Mr. HOLIFIELD. We are glad to have you with us, Commander Laub. We appreciate your statement, Mr. Secretary. Proceed, Commander Laub.

STATEMENT OF COMDR. ROBERT E. LAUB, CHIEF, ELECTRONICS PRODUCTION BRANCH, BUREAU OF AERONAUTICS

Commander LAUB. Mr. Chairman, I have a prepared statement here which I would like to read. I prepared this statement in connection with Mr. Fogler's wishes. This summary will show the events in the development of the TACAN system and additionally will show a summary of the Navy procurement of VOR equipment as was requested in Mr. Holifield's letter to Secretary Wilson.

Briefly, my background and perhaps what led to Mr. Fogler's very complimentary statement is that I happened to be in the electronics division when this development started. I then was transferred to Patuxent where a great many of the early tests were developed on this system and I am now back in production on the production aspect of it so my background either fortunately or unfortunately placed me in this position of knowing a great deal about the overall program.

To proceed with the chronology that I have there will be some repetition of what Mr. Quarles said, but I believe in order to have all the events in one straightforward sequence that it would be best to read through and recognize that there will be some repetition, so I will proceed, then, with the chronology that I have prepared.

During the period from 1943 to 1947 a requirement developed for a new carrier homing, later changed to carrier navigation system to replace the YE–YG which was considered obsolescent. Naval Research Laboratory was working on this problem and the requirement was considered pressing by 1947.

On February 26, 1947, the Chief of Naval Operations established military requirements for carrier navigation system.

Later in 1947 the Bureau of Aeronautics and the Bureau of Ships solicited proposals from Sylvania, RCA, Bendix Radio, Federal, and Sperry for a new carrier homing system. Federal and Sperry submitted proposals and the Federal proposal was selected.

In June 1948 a contract was let to Federal Telecommunications Laboratory for the development of the ARN–16 (airborne equipment) and URN–1 (surface equipment), based upon Federal's proposal. This equipment provided azimuth information only. The resulting equipment was demonstrated by the contractor in June 1950 and delivered in late 1950. The AN–ARN–16 was delivered as an operating breadboard rather than a completely developed equipment, ready for production. This was done as an economy measure, since the ARN–16 had served its purpose of proving the practicability of the TACAN azimuth system and since the ARN–21(XN–1) was under development.

In June 1949 a contract was let to Federal Telecommunications Laboratory—FTL—for the ARN–21(XN–1) and URN–3(XN–1). This equipment was to use the same principles as the ARN–16, URN–1 for providing azimuth information and, in addition, was to indicate the distance of the aircraft from the ground station.

In June 1950 BuAer let contract NOas–12205 for 10 evaluation models of the ARN–21(XN–1).

In July 1950, BuAer requested speedup on NOas–12205, authorizing overtime or additional shifts.

During September 1950 the ARN–21, URN–3 was demonstrated to a joint communication electronics committee—JCEC—working group.

In 1951 the ARN–21, URN–3 system was adopted by JCEC as the combined CAN–US–UK tactical air navigation system. In this same period the USAF and the UK presented their requirements which changed the system performance. A new specification was written and incorporated into NOas–12205 on February 28, 1951. This become the ARN–21(XN–2). The new requirements consisted of increased accuracy, increased channels and extended coverage.

In March 1951 the ARN–21(XN–1), URN–3(XN–1), although not yet completed were evaluated by Commander, Operational Development Force, COMOPDEVFOR. The COMOPDEVFOR report on this evaluation was that the system was satisfactory and recommended priority action on production.

In June 1951 first letter of intent for production signed with FTR.

In June 1951 a joint USN–USAF TACAN Steering Group was established.

In December 1951 NObsr 57103 awarded to FTR for production of AN–URN–3 equipment.

During February 1952 the contractor conducted extensive demonstrations of the ARN–21(XN–2), URN–3(XN–2) for USN, USAF, UK and Canadian observers.

The first of 40 development models of ARN–21 was delivered in September 1952. The remainder were delivered during the succeeding 12 months. These equipments were subjected to the following tests and evaluations:

(*a*) Design approval tests conducted by the Naval Air Development Center, NADC.

(*b*) Traffic-handling tests—conducted by the Naval Research Laboratory.

(*c*) Operational Evaluation—conducted by COMOPDEVFOR.

(*d*) System (ARN–21, URN–3) Engineering Evaluation—conducted by Melpar under USAF contract.

(*e*) System Engineering evaluation—by Naval Air Test Center, NATESTCEN, Patuxent. During this same period other test projects on a smaller scale were conducted by Wright Air Development Center, WADC, and Rome Air Development Center, RADC.

In October 1952 preliminary model of AN–URN–3 constructed under R&D Contract and NObsr–49248 delivered and was tested at NATESTCEN, RADC and WADC.

In May 1953 three AN–URN–3 pilot run equipments were delivered for evaluation and test. One of these units was furnished to the Air Force for evaluation and two to COMOPDEVFOR, Atlantic City, New Jersey.

In January 1954 first production ARN–21 deliveries were made from FTR. A total of 400 sets were released for production and as these sets were delivered, they were assigned to further test and evaluation projects at:

(*a*) COMOPDEVFOR.
(*b*) NADC.
(*c*) NATESTCEN.
(*d*) Navy Maintenance Training Activities.

(*e*) Air Proving Ground (USAF).
(*f*) WADC.
(*g*) RADC.
(*h*) Alaskan Air Command.

In January 1954 as the various tests and evaluations uncovered equipment deficiencies, either in performance or reliability, these deficiencies were evaluated and appropriate changes incorporated into production. As a result of the constant flow of changes the first 400 sets are not all the same but are of gradually improving quality.

In September 1954 Letter Contract NObsr–57103 was executed by the Bureau of Ships and FTR into a definitive contract for the production of 625 AN–URN–3 equipments.

In January 1955 production of the ARN–21 was released on a model meeting essentially all the specifications and incorporating the design changes which experience with the first 400 sets proved desirable.

In January 1955, 55 production models of AN–URNZ–3 equipment delivered to date.

At the present time there are a total of 5 contracts to 3 different manufacturers for production of AN–ARN–21 equipments.

The first is NOas 51–1227 with Federal Telephone & Radio Co. on which there are a total of 2,935 equipments. The original letter of intent for 1,001 equipments was dated June 19, 1951, and was subsequently amended to add 10 equipments for the USAF on October 10, 1952, with an additional amendment adding 1,924 equipments on March 19, 1953. The additional 1,924 were to cover requirements of 780 for the Navy and 1,144 for the USAF. On June 30, 1953, a quantity was added for MDAP for the United Kingdom and of the 2,935 on the present contract executed on February 26, 1954, 1,359 are for Navy, 1,154 for USAF and 422 for MDAP. The total money on contract 51–1227 is $33,380,153 which is subject to redetermination downward and includes spare parts to support installed equipments.

There are two other contracts with Federal Telephone & Radio Co., one subcontracted to Stromberg-Carlson Co., and one subcontracted to Hoffman Laboratories. Both contracts are for 250 each are still in letter of intent form. The subcontract with Stromberg-Carlson is NOas 52–260 for a total price of $2,857,464 and the subcontract with Hoffman Laboratories is NOas 52–1155 at a total cost of $2,744,565. These contracts were established in order to provide these two subcontractors with the necessary engineering information so that they could produce equipments under their prime contracts which could meet the same performance specifications and be interchangeable with those produced under Federal Telephone & Radio contract NOas 52–446r with the Stromberg-Carlson Co. and was originally issued as a letter of intent for 500 equipments on November 21, 1951. The letter of intent was later amended in March 1953 to add 3,152 equipments, 1,540 for the Navy and 2,112 for the USAF. There are 3,652 equipments presently on this contract at a total contract price of $30,975,866. The firm contract was executed on August 9, 1954, and is subject to redetermination downward.

Mr. BALWAN. This is all airborne equipment you are talking about?

Commander LAUB. Yes.

Mr. BALWAN. That is the airborne part?

Commander LAUB. Yes, sir.

Mrs. GRIFFITHS. It is also for redetermination upward?

Commander LAUB. No, just downward.

Mr. BALWAN. At what point would the redetermination come in?

Commander LAUB. It is usually 40 percent. We can give you that information; I think it is 40 percent.

The last of the five contracts mentioned is NOas 52–445r with the Hoffman Laboratories and was originally issued as a letter of intent for 500 equipments on December 6, 1951. In March 1953 the letter of intent was amended to add 2,175 equipments, 780 for the Navy and 1,395 for the USAF. There are now 2,675 equipments on this contract which was executed on October 29, 1954, at a total contract price of $24,576,255.

Of the total 9,762 equipments now on order, 4,679 are for the Navy, 4,661 for the USAF and 422 are for MDAP. Existing AN–ARN–21 contracts include a total of $92,713,579 of which $46,949,514 are from Navy funds, $40,361,871 are from USAF funds, and $5,402,193 are from MDAP funds.

Mr. BALDWAN. These are amounts obligated for production units?

Commander LAUB. That is right.

Mr. BALWAN. These do not include developments?

Commander LAUB. That is right. I cover that later.

Deliveries to date have consisted of approximately 400 sets which were conditionally accepted as a pilot production with the understanding that the contractors would rework these sets to incorporate changes required to make them meet equipment specifications. Federal Telephone & Radio has delivered 200 sets on NOas 51–1227, Stromberg-Carlson Co. has delivered 50 on their subcontract NOas 52–260 and 50 on their prime contract NOas 52–446, and Hoffman Laboratories has delivered 50 on their subcontract NOas 52–1155 and 50 on their prime contract NOas 52–445.

Further deliveries have just recently been released on the basis that certain changes would be incorporated in the first sets to be delivered and all known changes required would be incorporated by the time 500 more sets were produced on contract NOas 51–1227.

These decisions to release were made only after agreement by cognizant personnel representing Navy, Air Force, and Secretary of Defense. Stromberg-Carlson Co. and Hoffman Laboratories have received the same release with all 3 manufacturers being held to a maximum delivery rate of 80 equipments per month until the delivery of the equipment with the last known required change incorporated. At this point it is assumed that sufficient information will be available so that the manufacturers can then proceed to build up to their tooled rate of a combined total of 1,335 equipments per month.

The Bureau of Ships has contract NObsr–57103 executed October 20, 1954, for AN–URN–3 equipments to meet requirements for shipboard use, ground installations for Bureau of Aeronautics, USAF, United Kingdom and Australia. There are a total of 625 on contract at a total contract price of $67,384,603. At this point 101 equipments have been delivered on this contract.

Amendment No. 7 to letter of intent NOas 51–1227 dated June 19, 1951, adds approximately $2,139,000 for special tools and test equipment. Deliveries of test equipment are expected to start in May 1955.

From 1948 to the present date the Bureau of Aeronautics has expended approximately $5,167,190 on research and development programs associated with AN–ARN–21 and the Bureau of Ships has expended approximately $4,559,703 on research and development programs associated with the AN–URN–3.

The Bureau of Aeronautics has procured two types of VOR equipment to satisfy requirements for naval aircraft use, the AN–ARN–14 and associated indicators and the AN–ARN–30 with its associated indicators. The AN–ARN–14 was procured for those aircraft requiring the more complex equipment and the AN–ARN–30 where the simpler version would suffice.

To date 6,818 AN–ARN–14's have been procured by the Bureau of Aeronautics through the USAF at an average cost of $2,200 per equipment. In addition the Bureau of Aeronautics has procured through the USAF the ID–250–ARN and the ID–249–ARN to provide instrumentation to the AN–ARN–14 and other equipments. There have been 21,184 ID–250–ARN indicators procured and 12,003 ID–249–ARN—or equivalent—procured. The average unit cost of the ID–250 is $256 and the ID–249 is $950. The military interdepartmental procurement requests cover the period from February 20, 1951, to February 3, 1953, and involve a total of $31,825,554.

The Bureau of Aeronautics has procured 4,418 AN–ARN–30 equipments over the period from June 30, 1951, to January 14, 1953, for naval aircraft use and an additional 832 for Coast Guard, USAF, and Signal Corps. The 4,418 equipments for use in naval aircraft have cost a total of $4,508,575 and those for the other three users $1,158,256. In order to provide indicators for use with the AN–ARN–30, 5,836 ID–48–ARN indicators have been procured at a cost of $875,400.

This completes the summary of the development and procurement history of TACAN and a summary of procurement of VOR by the Navy.

Mr. HOLIFIELD. You have given us quite an array of figures there. What is the total that you have expended in the TACAN's development? Do you have a total of all those figures, of the lead figures there, the different procurements?

Commander LAUB. For the procurements?

Mr. HOLIFIELD. In the different procurements.

Commander LAUB. For the procurement of the equipment to equip aircraft the figure is in the nature of $170 million and development is in the order of 10 to 11 million dollars.

Mr. HOLIFIELD. Those are firm contracts for procurement?

Commander LAUB. That is right, sir.

We will be very happy to provide a complete breakdown with all of the accurate figures showing you the entire summary but at this point those are very rough.

Mr. HOLIFIELD. This does not include anything except Navy?

Commander LAUB. It does include Air Force in the ARN–21 procurement and URN–3 procurement. It does include some money which the Air Force has contributed to the development programs.

Mr. HOLIFIELD. But it doesn't include all of the Air Force expenditures?

Commander LAUB. I couldn't comment on that, sir. I could not answer that. We can provide that information, if you would like, also, in the cost breakdown.

Mr. GARDNER. I can answer that, sir. It does not.

Mr. HOLIFIELD. Now, Commander Laub, will you, for the benefit of the committee where you can, where security isn't involved, will you designate in the pages of your testimony, these different letter designations and tell us what the purpose of the different instruments involved are?

Commander LAUB. Yes, sir, I will.

Are you referring to the ID?

The ARN–21 is the airborne component of TACAN. The URN-3 is the ground component of TACAN. The ARN–16 was the early development which led to TACAN but which provided bearing, only, and that development has never gone beyond the breadboard stage.

Mr. BALWAN. What do you mean by breadboard?

Commander LAUB. Only the working model. It doesn't have the production techniques that you would see in a piece of equipment you would expect to put into production. It is a working model that demonstrates a principle or that shows technically such an approach is feasible.

Mr. BALWAN. ARN–16 never reached beyond the breadboard stage?

Commander LAUB. That is right.

The URN–1, of course, was the ground component of the ARN–16 which, again, had azimuth only in it and it was superseded by the URN–3 which did have the bearing and distance features in the equipment. I am sorry. I did not make references to pages. Did you want pages?

Mr. HOLIFIELD. No, as long as you have designated it for the record. You haven't left any of the technical designations out now, have you?

Commander LAUB. No, sir; I don't believe I have.

Mr. BALWAN. How about the ID?

Commander LAUB. I will explain that in a moment. The ARN–14 is the next one I see. That is a piece of equipment that is a great deal more automatic than the ARN–30, in that it has a selector box and has controlled channels and it will operate the ID–250 and the ID–249, the ID–250 being a dual-pointer—let me check for sure. Am I right, Gill?

Mr. HARDING. Yes.

Commander LAUB. It is a double pointer with a movable card behind, which will present bearing information in the same way, if you are familiar with the dual ADF, used on the low-frequency direction finders, in the same way that presentation is shown. It shows instantaneously the bearing of the ground station, or the bearing that you have with respect to the ground station. ID–249 is a deviation indicator that combines the cross-pointer information, the glide slope, and the deviation information, and it also incorporates in a sense a computer which allows you to fly your approach to the selected course somewhat better than you can with a standard cross-pointer indicator.

The ID–48 is simply a cross-pointer indicator. It has no other function but that. It has glide slope and deviation indication.

ARN–30 is a variable-tuned equipment. By that I mean it is not crystal-controlled and that you must select and listen to your identification to establish the fact that you have tuned to the station that you want to. It is simpler and cheaper.

Mr. HOLIFIELD. Now, are all these devices—do they all perform a different function, or are some of them substitutes for former items which you have procured?

Commander LAUB. The omnirange equipment, the VOR equipment—the ARN–30 does not do as much as the ARN–14 does, but it can be substituted in smaller aircraft where you want only the deviation and do not require the ADF type provision. Neither the ARN–14 nor the ARN–30 will substitute for the ARN–21.

Mr. BALWAN. What is ARN–30? Is that the VOR?

Commander LAUB. Yes, sir.

Mr. HOLIFIELD. You are going ahead with production contracts on all of these devices?

Commander LAUB. We have essentially completed those contracts for deliveries on the ARN–30 and the ARN–14 and are using those equipments. We have been for some time.

Mr. BALWAN. You have completed the ARN–30 contracts?

Commander LAUB. Yes, sir.

Mr. BALWAN. That is the VOR contracts?

Commander LAUB. That is right.

Mr. BALWAN. All your VOR are installed and operating?

Commander LAUB. All of those with the exception of spare support.

Mr. BALWAN. How many ARN–30's did you buy?

Commander LAUB. I will have to check but I think it was 4,418, if I can check here a minute. 4,418 is right.

Mr. BALWAN. You have them installed?

Commander LAUB. I couldn't answer absolutely, but essentially we have most of those installed and we have bought them to be installed in aircraft. We would have to check to give you a complete breakdown on it.

Mr. BALWAN. You have no more outstanding contracts for the production of the VOR's?

Commander LAUB. No, sir. Well, I wouldn't answer. We probably have some contracts that are still active where we may be getting spare parts or something like that. We have received delivery on most of those equipments that are intended to be installed in aircraft.

Mr. BALWAN. Mr. Chairman, the only observation I have at this point, until we get a chance to study this very complex document, is that the Navy was going in full force on the development and particularly the production of this thing long before the decision on the use of VOR or TACAN which came from ANDB only on February 28, or something like that.

Would you explain that?

Commander LAUB. I could give you my opinion. I think a lot of this, of course, will have to be substantiated with background information, but it is just a matter that the decision was made there were not going to be many low-frequency ranges around the country and in order to fly around the country we had to have something, so we had to get VOR in order to operate.

Now, the fact that the low-frequency ranges are still in existence, you might say, "Well, we made a mistake," we will grant we might have, but at the time we bought VOR we were told there would be no low frequency.

Mr. BALWAN. You couldn't put VOR into upper frequencies?

Commander LAUB. I don't understand your question.

Mr. BALWAN. Is there any way you could have modified ARN–30 to operate in the higher frequencies?

Commander LAUB. Well, I think Mr. Quarles answered the question better that I could. I believe he commented on that. Anything else I think would take a little study in order to provide you a good answer.

Mr. BALWAN. I thought he said the Navy would give us the answer on that.

Commander LAUB. I wouldn't dispute that at all. I am not too sure of that particular point but I believe this would take some research in order to give you the right answer.

Mr. BALWAN. Mr. Chairman, I think it would be very helpful to the committee to get whatever information the Navy has to show to what degree they participated in any research which would enable getting equipment by modification of VOR, rather than proceeding on an entirely independent tact, after the military department had decided upon a common system which would use VOR–DME.

Mr. HOLIFIELD. Would you furnish us anything you have on that point, sir?

Commander LAUB. We will.

Mr. HOLIFIELD. You have let contracts for $170 million on this TACAN development with $10 million to $11 million worth of research and development.

Now, that can only be justified on the basis of need, and, of course, on its operability.

Now, what can you tell us, from the standpoint of your position, about the operability of this equipment? Its reliability? Its degree of accuracy?

Commander LAUB. I think that also would require documentation. I think Mr. Quarles' comment was good. I have no reason to comment on the question of reliability. There are figures on reliability which can be obtained and which can be made available to you but at this point, without those figures, I would hesitate to give you commitments.

Mr. HOLIFIELD. Mr. Gardner, would you care to comment on that? Do you have any knowledge of it?

Mr. GARDNER. Yes, sir, I am a member of the Air Navigation and Development Board and as such I am responsible, along with Mr. Quarles, for making these decisions. I do have some knowledge on it. I intended in my statement to face up to the question of reliability and tell you what we can here today, and invite the committee to come out and fly in the airplanes and see just how the equipment performs. I think that would give you—I find it is very hard as I watch the witnesses, to get across to you the nature of the problem without actually going out and seeing it. If you could do that, I would like to extend an invitation on the part of Mr. Quarles and myself, to actually do that and get the physical feel for it. If you would like to wait until I come to my statement, sir, I do intend to face up to that question.

Mr. HOLIFIELD. Unless there are questions of Commander Laub at this time we will go ahead with Mr. Gardner's statement and we can come back to Commander Laub.

Are there any questions from the members at this point? We will come back to it in any event. Perhaps Secretary Gardner's presentation will answer some of our questions in advance.

Mr. GARDNER. I had a prepared statement which I think has been covered so it would be reasonably redundant. If I may, I will just speak off the cuff and address myself to the questions which were raised here this morning.

Mr. HOLIFIELD. Do you have copies of your statement?

Mr. GARDNER. It is not in a form that I think should be submitted.

Mr. HOLIFIELD. Will you go ahead and address yourself to those questions and give us any other information which you may have pertaining to it.

Mr. GARDNER. I would like to talk a little bit about the amplification of the background. We have asked Mr. Balwan what questions you had and we would like to address ourselves to the requirement. I think it is extremely important to come back to Mrs. Griffiths' question this morning about safety and we intend to do that.

We would like to give you a more concise summary on cost. We would like to file with you, separately, an accurate chronology of those decisions which were made within the Defense Department, and of those letters which were sent over from Commerce, indicating the exact time at which there was a knowledge that TACAN existed. We will follow that chronology.

(Fiscal summary, submitted subsequent to hearings follows:)

FISCAL SUMMARY

A complete summary of the expenditures for both research and development and production of the TACAN system from 1947 till today is contained on the following sheets.

Sheets 2 and 3 show a total of $9,540,528 spent for research and development of the TACAN system.

Sheets 4 and 5 show a total of $165,506,764.14 spent for production of the TACAN system, exclusive of installation costs.

Additional information regarding the procurement of ground and airborne VOR equipment is included to complete the procurement picture.

Sheet 6 shows a total of $14,645,711 spent for VOR ground stations, exclusive of actual installation costs.

Sheets 7, 8, and 9 show a total of $88,434,211 spent for VOR airborne equipments and associated indicators, exclusive of installation costs.

Bureau of Aeronautics expenditures for developments associated with the airborne portion of the TACAN system (AN/ARN–21)

Contract No.	Contract date	Item	Contractor	Price	
				BUAER	*USAF*
NObsr-42422	June 29, 1948	AN/ARN–16 (XN–1)	Federal Telecommunications Laboratories.	$220,000	
NObsr-43365	June 16, 1949	AN/ARN–21 (XN–1)	do	170,000	
NOa(s)-12205	June 19, 1950	AN/ARN–21 (XN–1)	do	122,850	
Amendment No. 2		Change specifications to AN/ARN–21(XN–2)		594,981	
Amendment No. 3		AN/ARN–21(XN–2)		390,184	
Amendment No. 6		Drawings of AN/ARN–21(XN–2)		11,641	
Amendment No. 16		Spare parts		99,012	
Amendment No. 17		Overrun		165,000	
NOas 52-855-c	May 2, 1952	Overrun on NOa(s)-12205	Federal Telecommunications Laboratories.	446,172	
NOas 53-973-c	April 30, 1953	do	do	130,434	
NOas 52-293-c	Nov. 10, 1951	ID-326/ARN-21 combined azimuth-range indicator (partially terminated to reduce cost from $146,584 to $68,894).	do	68,894	
NOas 52-623-c	Mar. 21, 1952	AN/ARN-21(XN-10)	Collins Radio	239,823	
		Installment		150,000	
		Installment		239,257	
		Installment		296,852	$179,493
NOas 53-076-c	Oct. 3, 1952	Ramp test equipment for AN/ARN-21	Hoffman Laboratories	319,739	
NOas 53-975-c	June 3, 1953	Special test equipment for AN/ARN-21	Federal Telecommunications Laboratories.	550,000	550,000
NOas 55-192-c	Dec. 3, 1954	Design improvements to AN/ARN-21	do	118,413	118,413
MIPR R53-1835-6-Aer	July 7, 1952	TACAN engineering evaluation USAF (Melpar) (also supported by BuShips and USAF).		175,000	
Amended	July 24, 1953			14,667	
Total				4,522,919	847,906
				5,370,825	

For production of TACAN system the Bureau of Ships has under contract the following amounts for ground and ship installed equipments of AN/URN-3 and necessary maintenance support:

Contract No.	Date	Total quantity	User and quantity		User dollars
NObsr-57103	Sept. 20, 1954		BuShips		18,337,883
			BuAer		6,057,155
			USAF		38,848,862
			Australia		66,500
			U. K. (MDAP)		2,173,987
Total					65,484,387

A further breakdown of Bureau of Aeronautics procurement actions (summarized above) for AN/URN-3 is as follows:

PD/ICF	Date	Total quantity	User and quantity		User dollars
PD5398-52	Jan. 26, 1952		BuAer		2,400,000
Change A	May 1, 1952		do		640,000
Change B	June 22, 1954		do		1,903,292
PD5929-53	Feb. 19, 1953		do		819,900
PD4642-54	July 17, 1953	*Antennas only*	do		293,960
Total					6,057,155

In addition to the actual procurement of AN/URN-3 equipment the Bureau of Aeronautics has provided the following amounts to convert 11 AN/URN-3 to AN/MRN-16:

PD/ICF	Total quantity	User and quantity		User dollars
PD-4642-54 and POAR-40713	4			262,114
ICF-33-55 and POAR-40710	7			385,000
Total				941,074

NOTES

PD refers to Bureau of Aeronautics Procurement Directive.
ICF refers to Intrabureau Citation of Funds.
POAR refers to Project Order Action Request.
The AN/MRN-16 is a mobile air navigational aid consisting of an AN/URN-3 (TACAN) equipment installed in a van on an M-35-type truck.

For production of TACAN system the Bureau of Aeronautics has under contract the following amounts for airborne equipment of AN/ARN-21 and necessary maintenance support:

Contract No.	Date	Total quantity	For—		Cost	Total cost
NOas 51-1227r	June 19, 1951	2,935	Navy	1,359	$15,880,002.25	
			USAF	1,154	12,097,957.20	
			MDAP	422	5,402,193.63	$33,380,153.08
NOas 52-446r	Nov. 21, 1951	3,652	Navy	1,540	13,791,870.75	
			USAF	2,112	17,543,996.09	31,335,866.84
NOas 52-445r	Dec. 6, 1951	2,675	Navy	1,280	11,675,611.41	
			USAF	1,395	11,279,143.88	22,954,755.29
L/I NOas 52-260	Sept. 24, 1952	250	Navy	250	2,857,464.58	2,857,464.58
L/I NOas 52-1155	do	250	do	250	2,744,565.35	2,744,565.35
						93,272,805.14
Test equipment:						
NOas 51-1227r	June 19, 1951	101	do	101	2,139,000.00	2,139,000.00
NOas 52-445r	Dec. 6, 1951		do		1,621,500.00	1,621,500.00
PD EN11-3902-55						80,000.00
		9,863				3,840,500.00
Facilities contracts:						
NOas 53-129C (SC)						208,000.00
NOas 53-130C (Hof)						225,000.00
NOas 53-122C (Fed)						[1] 535,000.00
						968,000.00

[1] Total contract price, but only 250,000 released.

L/I indicates Letter of Intent.
PD refers to Bureau of Aeronautics Procurement Directive.

The Bureau of Aeronautics has initiated procurement action through the Bureau of Ships for the following ground VOR equipments:

PD/ICF	Date	Quantity	User	Dollars
PD 7483-51	Oct. 20, 1950	{15 AN/FRAN-12A 5 AN/MRN-9	BuAer	1,618,742
ICF-150-55	Jan. 21, 1955	5 TVOR		125,000
				1,743,742

The AN/FRN-12A's (VOR equipment) are scheduled for installation at the following activities:

Corpus Christi	El Toro	Olathe
Kingsville	Fallon	Patuxent River
Chase	Oceana	Pensacola
Cecil Field	Whidby Island	Quonset Point
Cherry Point	Brunswick	Willow Grove

The AN/MRN-9's (VOR equipment) are scheduled for installation at the following activities:

Atsugi	Iwakumi	Sangley Point
Hutchinson	Port Lyautey	

The TVOR equipments are scheduled for installation at the following activities:

Cubi Point	Atlantic City	Kaneohe
El Centro	Guantanamo Bay	

NOTES

PD refers to Bureau of Aeronautics Procurement Directive.
ICF refers to Intrabureau Citation of Funds.
AN/MRN-9 is a mobile version of the VOR ground station.
TVOR refers to a terminal VOR.

To equip naval aircraft with airborne VOR receivers the Bureau of Aeronautics has procured AN/ARN-14 (less ID-249 and ID-250) as follows:

MIPR No.	Date	Total quantity	User and quantity		User dollars	Total dollars
5105-51-1	June 23, 1950	1,319	Navy	1,245	3,360,355	
			MDAP	74	189,746	3,550,101
5179-51-79	Feb. 20, 1951	280	Navy	272	448,819	
			Coast Guard	8	17,881	466,700
2129-52-77	June 2, 1952	543	Navy	516	1,176,056	
			Coast Guard	27	48,005	1,224,062
2776-53-56	Oct. 1, 1952	2,452	Navy	2,452	4,584,034	4,584,034
2884-53-130	Feb. 3, 1953	2,216	do	2,191	4,778,164	
			Coast Guard	25	42,650	4,820,814
Total		6,810				14,645,712

NOTES

Above total includes quantities excess to Navy requirements, this surplus will be reduced by reimbursable transfer to USAF to meet existing USAF requirements.
MIPR refers to Military Interdepartmental Procurement Request.
The average unit cost for AN/ARN-14 above not including the ID-249 and ID-250 is $2,200.

The Bureau of Aeronautics has procured the following AN/ARN-30 airborne VOR:

Contract No.	Date	Quantity	User and quantity		User dollars	Total dollars
NOas 12281	June 30, 1950	3,520	Navy	2,876	2,645,588	
			Signal Corps	643	968,211	
			Engineer Corps	1	1,121	3,614,920
NOas 52-608	Mar. 26, 1952	168	Navy	160	195,258	
			Coast Guard	8	7,294	202,552
MOas 53-501	Jan. 14, 1953	146	Air Force	146	150,087	150,087
NOas 53-235	Nov. 13, 1952	1,416	Navy	1,364	1,754,119	
			Coast Guard	52	31,543	1,785,662
Total		5,250				5,753,221

NOTE.—All contracts shipped complete.

ID-48/ARN

MIPR and contract No.	Date	Quantity	User and quantity	
NAVAER 01187	July 11, 1951	34	Navy	34
2085-52-48(MIPR)	Aug. 1, 1951	156	do	156
2269-52-105(MIPR)	Aug. 1952	59	do	59
2433-54-5(MIPR)	Apr. 1, 1953	1,285	do	1,232
			Coast Guard	53
NOas 53-235	Nov. 13, 1952	1,416	Navy	1,382
			Coast Guard	34
NOas 12281	June 28, 1951	2,736	Navy	2,736

SUMMARY

User and quantity		User dollars
Navy	5,599	1,209,384
Coast Guard	87	18,792
Total	5,686	1,228,176

NOTE.—NAVAER-Navy order on Air Force stock.

ID-250

MIPR No.	Date	Total quantity	User and quantity	
5105-51-1	23 Jan 1950	1,319	Navy	1,245
			MDAP	74
5179-51-79	20 Feb 1951	1,879	Navy	1,798
			MDAP	65
			Coast Guard	16
2085-52-48	Fiscal years 1951 and 1952	3,931	Navy	3,897
			MDAP	34
2810-53-159	Fiscal years 1950 through 1954	11,485	Navy	11,360
			MDAP	34
			Coast Guard	91
2655-55-116	Fiscal years 1954 and 1955	1,480	Navy	1,418
			MDAP	62
2129-52-77	2 Jun 1952	1,090	Navy	1,040
			Coast Guard	50
3865-50-59	Fiscal year 1950	8	Navy	8

SUMMARY

User and quantity		User dollars
Navy	20,706	5,316,096
MDAP	269	68,864
Coast Guard	157	40,192
Total	21,192	5,425,152

NOTE.—The ID-250 is used both with the AN/ARN-14 and the AN/ARA-25 (a UHF automatic direction finder).

ID-249/ OR 387/ OR 351/ARN

MIPR No.	Date	Total quantity	User and quantity	
3865-50-59	Fiscal year 1950	8	Navy	8
5105-51-1	Fiscal years 1949, 1950, and 1951	1,319	do	1,245
			MDAP	74
5179-51-79	Fiscal year 1951	313	Navy	305
			Coast Guard	8
2085-52-48	Fiscal years 1951, 1952, and 1953	1,186	Navy	1,169
			MDAP	17
2129-52-77	Fiscal years 1951 and 1952	163	Navy	123
			Coast Guard	40
2432-54-6	Fiscal years 1951, 1952, 1953, and 1954	5,375	Navy	5,340
			Coast Guard	35
2593-55-82	Fiscal years 1951, 1952, 1953, 1954, and 1955.	2,233	Navy	2,233
2648-55-115	Fiscal years 1951, 1952, 1954, and 1955	1,384	do	1,384

SUMMARY

User and quantity		User dollars
Navy	11,807	11,216,650
MDAP	91	86,450
Coast Guard	83	78,850
Total	11,981	11,381,950

NOTE.—The ID-249 is used with both the AN/ARN-14 and the AN/ARN-21.

We would like to address ourselves to the state of development today, and that includes reliability. If that meets with your approval we will proceed.

When we came into this problem approximately 2 years ago, the civilian management of the Defense Department inherited the problem and we immediately attempted to face up to the dilemma that Mr. Quarles described this morning. I would like to just restate that

we didn't proceed to make an immediate, irrational decision. We called for the opinion of the Air Navigation Board and we tended to bring to bear on it the best technical competency in this country. I believe we were successful. When we had this evaluation we studied it and we weighed that as evidence in arriving at our decision. I believe we made the right decision, but if some facts can be developed to prove we didn't, that is a separate question.

Perhaps it would be well at this point to just outline my understanding of the Air Force's investment and interest in both the VOR and TACAN. In the TACAN there is being procured for the Air Force, 4,651 ARN–21's, 143 TRN–6's, and 423 URN–3's. I think the meaning of those designations has been put into the record earlier, and 50 A–TRN–6's. This amounts to an investment exclusive of installation costs, of about $100 million. I think the figure is 98.8—we will supply you the exact accurate figure later. These are for installation on the ground and in Air Force aircraft. In the VOR's we are producing no DME's though we have procured 5 DME ground stations. In the VOR's we are securing 26,000 and they are being distributed, 5,500 to the Navy—that is why I mentioned earlier that the Navy would be getting additional ones over the 4,800 they have now.

Mr. HOLIFIELD. You are still continuing to plan to use them?

Mr. GARDNER. Right. Procuring 26,000 and about 5,500 for the Navy, and the Coast Guard, 4,800 for spares and 200 for training—24,500 VOR's have been delivered, and 8,037 are presently installed in aircraft. That kind of gives you an overall picture of our situation.

Mr. BALWAN. Could you give us some idea of the unit cost? The testimony is that it varied from 500 to 4,500.

Mr. GARDNER. We have been using the figure of 3,500 for the VOR's. We will have to vertify that figure for you. I believe it is a reasonably good figure.

Commander LAUB. I gave very nearly 3,500.

Mr. BALWAN. When speaking of VOR equipment, is that similar to that in commercial use, or does the Air Force and the Navy have a piece of equipment which has several military specifications on top of that which makes it more expensive?

Commander LAUB. The ARN–14 is essentially the equivalent of the Collins 51–R–1, 2 and so forth. It appeared we could buy 51–R in the same way we buy ARN–14. For all practical purposes, they are the same and they are the same in cost.

Mr. GARDNER. In addition to this overall financial interest in the program, we have a deep interest in our assigned responsibility for continental defense. I think Mr. Quarles touched on that this morning, but one of the new variables that has crept into this problem is that when the problem originally began, we didn't have the threat which caused us to think as seriously as we now have to about continental defense. Therefore, our interest in some of the tighter specifications of TACAN stem directly back in the case of the Air Force, to our need in the continental defense picture.

Mr. BALWAN. Could this be developed a little more in detail in executive session?

Mr. GARDNER. We can do that, yes.

If I could now talk about the requirement, perhaps that would be appropriate.

The fundamental requirement mentioned by Mr. Quarles is more accuracy. Let me see if I can give you a feel for what that means. The way in which I can visualize it is, 1° at 60 miles is a piece of air 2 miles across and 2,000 feet deep. The DME would provide us with 3° accuracy, or a piece of air 6 miles across, and about 2,000—DME–VOR—and about 2,000 feet deep. So we are talking about pulling in that piece of air, where you know you are, by that amount.

Now, it requires both an aviator and a ground control operator to tell you whether it is really important whether you know your accuracy within that distance. Our experts who have to fight the air battle believe that it is necessary. I think we can develop it further in executive session, but it is that kind of a chunk of air we are talking about, 60 miles from the receiving station.

Mr. BALWAN. How about accuracy?

Mr. GARDNER. Those are the limits of the accuracy.

Mr. BALWAN. Would you give that again?

Mr. GARDNER. When you receive a signal giving you a number you don't know where you are plus or minus 3 miles on either side of you, with DME.

Mr. BALWAN. With VOR?

Mr. GARDNER. With VOR, excuse me, and within 2,000 feet, on DME.

With TACAN you pull in the limits on each side of you to 1 mile and retain the same depth, 2.000 feet—four-tenths of a mile. I just rounded the number off.

This is probably an easy way—and it is for me, anyway—to visualize it.

So we need a requirement for greater accuracy.

We have a requirement for a great number of channels and we have a requirement for some security, which you can obtain with an agreed upon number of channels. We have a problem of having a system which can be used in a tactical war situation outside of the United States, and a system which can be used in conjunction with or at least not conflicting with our allies.

We have a requirement for as light a weight unit as possible and even though the testimony or the discussions this morning would not imply we have a need for a unit with extremely high reliability, we do.

Mr. HOLIFIELD. Can you tell us the difference in weight between the VOR–DME and the TACAN?

Mr. GARDNER. I don't recall it offhand, but we can get it.

Mr. HOLIFIELD. Have you obtained any objective there, in reducing weight?

Mr. GARDNER. Commander Cobb——

Colonel COBB. If they both developed the same standards, I believe there would be essentially no difference.

Mr. GARDNER. We still have the requirement for light weight. In these jet airplanes we will do almost anything to gain 10 pounds.

Mr. HOLIFIELD. You say if they are developed in the same degree?

Colonel COBB. Same degree of standards. I mean miniaturization techniques and using the premium quality tubes and so forth. To my knowledge there is no comparable DME—maybe Mr. Winnik from the Navy could tell us about that. I mean Mr. Harding.

Mr. HARDING. I think there would be essentially no difference in size or weight between the VOR–DME and TACAN, if you built the same order of reliability and same order of ruggedness, used miniature tubes in both, or subminiature tubes in both and the same general standards of construction.

Mr. HOLIFIELD. At the present time your TACAN's equipment is heavier? Your existing units that you are procuring are heavier, or lighter than the existing units of VOR–DME?

Mr. HARDING. Well, sir, there are available VOR airborne sets for the private flier which are considerably lighter than the ARN–14.

Mr. HOLIFIELD. We are in military procurement, now.

Mr. HARDING. I am trying to explain that you can take a VOR and a DME and come out with a much lighter weight than the ARN–21, but if you take a VOR airborne set and a DME airborne set which are of the same standard of quality, you will find they are of about the same weight. In fact, the figures that I have seen would indicate that the VOR–DME would be somewhat heavier.

Mr. FOGLER. I think, Mr. Chairman, we would like to get the accurate figures on that.

Mr. HOLIFIELD. You haven't achieved any advantage in weight by this change.

Mr. GARDNER. I wonder if I could interpose a thought here, sir.

VOR–DME ruggedized to meet present methods of operation, G's and unusual temperatures and so forth, I believe you pick up some weight. That is what happened to TACAN. I don't believe you can quite generalize it the way you have, sir. It is quite a technical question.

Mr. HOLIFIELD. Well, leave that aside. Now, tell us about the reliability of it.

Mr. BALWAN. Mr. Chairman, could I interpose a question here: There is an awful lot of talk about if we bring something up to certain standards. We are already in production for many thousands of units and I wonder why we don't know at this time. Are we still continuing to develop this thing.

Mr. GARDNER. Exactly, and we will for the next five years. We are still continuing to develop the B–36 and the aircraft carriers. We have put everyone of these things into production before they were ready. It is necessary. If we wait for the final development of any one of these devices, we will be hopelessly behind our enemy. It is necessary, within the spectrum of technical judgment that exists, to select a point at which to gamble on the design and gamble against losing the total race, or winning the total race. It means you must gamble on the design and all these devices quite early. This applies to aircraft, to engines and to electronics. More so in electronics because you have more points of failure. This is the reason that research and development is so complicated and we must be prepared to make mistakes. We must have the confidence that American ingenuity can correct these mistakes, about reliability. We have about 101 of these devices in the Air Force at this point. We have 50 of them either in aircraft or being installed in aircraft. We are acquiring hours of test. We have a list of bugs. The bugs are fixable. They are being fixed. Other bugs will develop. We will fix them and the reliability will slowly creep up to where it has to be. We

are not saying that these things are 100 percent reliable because you can't even say that about commercial aircraft or commercial radios.

We are saying that we are on top of the reliability program, that we are discovering the bugs as they appear, and are correcting them. We have an aggressive test program.

Mr. HOLIFIELD. You are also saying it is necessary to freeze into procurement contracts, $170 million worth of these devices before you get these bugs out? Is that what you are also saying?

Mr. GARDNER. Yes, sir.

Mrs. GRIFFITHS. Mr. Chairman——

Mr. HOLIFIELD. Mrs. Griffiths——

Mrs. GRIFFITHS. Actually, the contracts you are calling production contracts are actually research and development contracts, for all practical purposes?

Mr. GARDNER. Let's put it this way: All these contracts have a development and improvement component in them.

Mrs. GRIFFITHS. And you are asking for 10 years to try to develop TACAN's and knowing when you ask it that you can at present get something decidedly worthwhile but for 10 years you want to use the air to develop this particular device. Isn't that right?

Mr. GARDNER. I don't think as responsible management people in the Defense Department we have any alternative but to adopt the course of action we have.

Mr. GRIFFITHS. You have that third alternative that you could develop something else?

Mr. GARDNER. May I discuss the third alternative: We have a state of development and need for procurement and time, and civilian interest. There are four variables to play with here. Any solution that we come up with has to be a judgment compromise between our guess as to the state of development, our need for the procurement, how much time we can take before we have operational units and what it does to the civilian interests.

Now, this is a complex set of variables to play with and I don't think we have made with them irresponsibly. If we went the alternative route, just on a quick estimate, I think we are looking at a loss of time of not less than 2 years and probably 3. I don't think anyone can quite assess it accurately. I would like to refer that to someone in the Navy or the Air Force who has looked at it carefully.

Colonel COBB. At least 3 years.

Mr. GARDNER. I don't think anybody knows for sure but I am sure it is not less than two, and probably three. Now, our question as responsible people charged with air defense is, can we wait 2 years for the improvement, and we feel we cannot. There is our problem.

Mr. HOLIFIELD. Now, what do you gain by having 4,000 or 5,000 or 6,000 of these sets in operation? Are they operable to the extent that they are of value to you now, in operation, or are they all being utilized from an experimental standpoint? In other words, why can't you do the same job of research and development on 400 or 500, that you do on 4 or 5 thousand?

Mr. GARDNER. You lay out your procurement in a time scale and you try and outguess how long it is going to take you to work the bugs out. You know you will need certain basic components in any case and they have a long lead time. You can do just what you said, sir.

You can wait, but then your lead time starts after you make your production decision, so what we are doing, we are gambling lead time against our combined ingenuity, to outguess the bugs. This is what goes on in every one of these procurements. It just happens to show in this one.

Mr. HOLIFIELD. All right. Now, can you give us some information on the condition of these devices and how many bugs are in them now, and what degree of operability or reliability is contained in them?

Mr. GARDNER. I think we would have to do that in executive session.

Mr. HOLIFIELD. All right, we will get that in executive session.

Did you have anything additional?

Mr. GARDNER. Yes, we would like to take up if we may the question of safety which Mrs. Griffiths raised, and I think your question was, does the decision to take DME off the air make it less safe for civilians flying through the air space. Is this an accurate restatement?

Mrs. GRIFFITHS. That is correct.

Mr. GARDNER. I wonder if you would tackle that.

Colonel TAYLOR. I feel to answer this question I have to give some background, Mrs. Griffiths. It isn't that we haven't thought a great deal about this question because we have. When DME or the existing function was first put into the system, in S. C. 31, the function was not necessarily to improve safety because the safety was taken care of in other means. It was really to provide for reduced separation for en route traveling under instrument, flight rule conditions, as far as the route areas were concerned. Let's say reduce the separation from 10 minutes to 5 minutes separation, because DME would give you a continuous fix that the controllers could call on at any time, rather than the radio fixes which are now established along the Federal airways, and in the terminal area, it was to help the ground controller in a terminal area in flexibility, because he could require you to hold at any particular point, and also reduce his separations, from whatever his local standard was in air traffic control, to a safe separation which would only be safe because you had a continuous knowledge of the distance.

Mrs. GRIFFITHS. That makes it safer, doesn't it?

Colonel TAYLOR. It makes it safer in this respect at least: Once you decided you could reduce your separations because of the equipment you certainly wouldn't want to relax your safety. You would depend upon the equipment for nonrelaxation of safety rules.

I think the real answer to your question is, without distance information, the penalty we have paid is not one of safety, but the lack of immediate ability to reduce our separations in en route areas.

But there is another thing that must be examined, and we will talk about this, and that is, in the original concept——

Mr. HOLIFIELD. Will you please tell me what you mean by separation?

Colonel TAYLOR. Yes, sir. When aircraft depart, let's say from Washington to New York, under instrument flight rule conditions, where the pilot cannot conduct his flight by looking at the ground, the air traffic control assigns a takeoff and an altitude to each flight. Let's say the flight altitude is 7,000 feet. The next aircraft who takes off and is assigned 7,000 feet will very probably have in excess of 10 minute's time between the first departure and his own departure.

This is very expensive of air space. The tendency is to close up this distance, which is excessive at the moment. Of course, as the traffic gets faster, this separation in time is more expensive of air space and, therefore, the increased requirement for what is known as distance information, I believe.

Now, in the original SC–31—and forgive me if I seem to get technical here. I know no other way to explain it.

Mr. BALWAN. What is SC–31?

Colonel TAYLOR. Special Committee 31 of the Radio Technical Commission for Aeronautics. This was the group that got the Collier award for agreeing to a common system or development of a common system.

There was a requirement stated for what was called a rho-theta navigation system. "Rho" being distance and "theta" the angle from the ground station.

It would allow parallel tracks to be flown, instead of aircraft flying identical paths with time separating them. It is a simple mathematical exercise to sit down and describe the accurateness required for this. It will suffice to say for the moment that it is not a useful exercise to try to do this with the present lack of accuracy of the VOR.

Please bear in mind I am distinguishing VOR, from DME in this case. The DME accuracy is more suitable to this type of operation than the VOR. Also using the rho-theta system it would be possible to fly to any point where both distance and bearing signals are receivable by adding a device called "the off-course computer."

As Secretary Gardner brought out a while ago, at 60 miles, the accuracy is a block of air space 2,000 feet in depth and 3 miles on either side of the desired radial in case of VOR. In the case of TACAN, the distance remains the same. However, the azimuth portion is 1 mile on either side of the desired radial. This would allow true off-airways flying, such as the National Business Aircraft Association has stated it would do, with a far greater degree of accuracy. We could then in truth be flying a safe system because separation limits could be reduced effectively without risk of collision.

Have I shed any light on this situation, at all?

Mrs. GRIFFITHS. You say the TACAN's would make it safer?

Colonel TAYLOR. Always assuming the same degree of reliability.

Mrs. GRIFFITHS. Of course, DME is a safety device, too.

Colonel TAYLOR. In this case it is.

Mrs. GRIFFITHS. Do we give up DME to civilians for 10 years to take a fling at something we may develop, or we may not?

Colonel TAYLOR. I would rather not say that Mrs. Griffiths. I think the plan is that DME is put in a state of standby until we are sure TACAN can be adopted for common system use. Then if it is determined that it can, we make that decision. in which case we do not scrap the DME, we adopt another one. If it turns out TACAN is deemed unsuitable for common system use, we will go back to the DME that we now have, but on a full scale implementation basis because at the moment DME buys you nothing in safety, buys you nothing in traffic control. It does buy the National Business Aircraft Association the ability to assist their navigation off-airways.

This is what we are giving up at the moment. We have never reduced the separation standards to allow for DME use so we are not giving up any safety at all.

Mrs. GRIFFITHS. I thought you just said you were.

Colonel TAYLOR. No, ma'am. If we went to these new rules we would not be giving up safety if we have DME.

Mrs. GRIFFITHS. If you went to what?

Colonel TAYLOR. If we went to a shortened standard of separation which we could do with at least 50 percent implementation of DME, so I am told. Of course, now we have a very small percentage of implementation.

Mr. GARDNER. Suppose we try to reduce what Jack has said to a formal statement which we will supply to the committee. I think it is extremely important to get you a very clear answer to the question you asked.

Mr. BALWAN. May I ask a question in connection with Mrs. Griffiths' statement: Colonel Taylor stated that TACAN would come out with a better instrument for the National Business Aircraft Association than is available under VOR–DME?

Colonel TAYLOR. Yes, sir.

Mr. BALWAN. Does the National Business Aircraft Association know what TACAN can do, in view of the fact that it is classified?

Colonel TAYLOR. I can answer that in part, at least: The National Business Aircraft Association members who were present on the VORTAC Committee, which were Mr. Cole Morrow and Mr. Gene Dubuque, understand this and also the press release we put out gave them the accuracy figures as they have been established by the consultants. This information was declassified shortly after the course of action was developed by the board.

Mr. BALWAN. How long ago was that?

Colonel TAYLOR. It has been approximately 1 month.

Mr. GARDNER. Mr. Chairman, might I make one further comment on the production: As I understand it—and I think the Navy can verify this—even though the dollar numbers are large, we are presently in a state of limited production in component procurement based upon increasing reliability of the devices, as the improvements get into them. Can you verify that?

Commander LAUB. Yes, sir.

Mr. HOLIFIELD. In other words, the $170 million is not spent for an article in its present condition?

Commander LAUB. No, sir.

Mr. HOLIFIELD. It will be spent over a period of time as you improve this.

Commander LAUB. That's right.

Mr. HOLIFIELD. And over what period of time?

Commander LAUB. I would like not to answer it precisely, but give you an answer in this way, that we have limited it to 80 a month until somewhere about August or September of this year. At this point, they will start building up to their tooled rate and I believe this figure will carry out for approximately 18 months from now, but I can give you this contract schedule which will show the present schedule and the estimated delivery.

Mr. HOLIFIELD. This indicates, then, that you believe that by September of this year, you will have the bugs out of it enough to more or less freeze it?

Commander LAUB. I think in my prepared statement I indicated the assumption was made that we would have sufficient information

to allow them to proceed and I believe on the basis of the data we are obtaining today, and the indications of improvement in reliability, and the changes which are being made, when these first production sets that we are starting to get now are put into test, that it will show that we have improved the reliability to the point where it can be produced.

Mr. HOLIFIELD. Will you make that application to the deck of a carrier, the same as a stable point, like a land-based field?

Commander LAUB. I believe that if I were to rely completely on my memory, I could make a statement, but I would prefer to get the information and present it to you in the form of reports that we have on the accuracy information that has been obtained on tests aboard carriers. I believe that would be much better than to rely on my memory and things that I have heard.

Mr. HOLIFIELD. All right, we will expect that information, then.

Now, as to the reliability of this equipment, as distinct from the accuracy of it, Mr. Gardner.

Mr. GARDNER. I have been talking about a number of the factors. I think some of the detailed figures we would like to present in executive session. I know it sounds as though we are bringing a lot of stuff in later, but we only heard of this last Friday evening so we haven't had much time to prepare it.

Mr. HOLIFIELD. The committee is aware of that and will take that into consideration.

Mr. GARDNER. I would like to make one further statement about our plans for the VOR:

Those 26,000 VOR's will be obsolete by 1965. We use them in first-line aircraft and they are excellent devices until we have something better—namely the TACAN, to replace them with. As we take them out of first-line aircraft they will go into second-line aircraft and they will be pretty well used up and the taxpayers will have had their money out of them by the time we put them to rest.

Mr. HOLIFIELD. Mr. Eckhart would like to pose a question.

Mr. ECKHART. As I understand the presentation, here, the TACAN incorporates the features of VOR and DME. The counterpart of VOR in the TACAN set is being improved. The counterpart of DME in the TACAN equipment is just about the same as it was before. Is that correct?

Mr. GARDNER. In terms of what it will do for you, that is right.

Mr. ECKHART. Why have we procured 26,000 pieces of VOR equipment and only 3 or 4 pieces of DME, when one is a good piece of equipment and the other is questionable?

Mr. GARDNER. I would like to refer that question to General Blake if I may.

General BLAKE. I think the point that has been missed here—and it is pretty fundamental to the whole thing—is that the VOR and the azimuth portion of TACAN are not competitive and they are not incompatible. That is why we are using VOR and have been using VOR for years and will continue to use VOR until it has served its useful life. The distance-measuring portions of the civil system and the distance-measuring portions of TACAN are competitive and incompatible and that is the point we are trying to solve. That has been the case since they were invented shortly after the war. In fact, I might say it is well known to most of the people concerned with this problem.

Mr. BALWAN. Is the azimuth part of TACAN compatible with DME?

General BLAKE. Yes, I would say it is compatible. By that I mean they can coexist.

Mr. BALWAN. That is something we didn't know. It is a new piece of information.

General BLAKE. There is an argument over DME techniques and not over azimuth techniques.

Mr. BALWAN. So that TACAN can continue to be developed as DME is in existence?

General BLAKE. No, sir. That is the root of the problem. The competition and the incompatibility between the distance-measuring portions of these two systems. Not the azimuth portions. The important and fundamental fact that has to be kept clearly in mind.

Mr. FASCELL. Accuracy in azimuth is also important, isn't it?

General BLAKE. Well, yes, sir, there are other factors in TACAN besides the question of accuracy.

Mr. HOLIFIELD. Mr. Gardner, go ahead.

Mr. GARDNER. I have just one other statement: While all of this evolutionary process has been going on, a number of other evolutionary processes have been going on which bear on it—the evolution of improved components, for example, the understanding a little more about good mechanical engineering as applied to electronic gadgets, and the development of a ground environment system in the continental defense net, and what effect all this will have on our future judgments is very difficult to assess, but a portion of our judgment was related to trying to anticipate what might occur later in these fields.

That's all I have to say, sir.

Mr. KILGORE. There are some physical phases of this thing I would like to ask somebody about. Perhaps it should be done in executive session. I am sure there are some questions in connection with the practical effect of a homing feature of this system as compared to something else, which may be a consideration. Those are things that I think would be of particular importance to the committee. If those are matters that should be gone into in executive session, that might be done.

Mr. GARDNER. I think we could give you an answer in executive session much better than we can here.

Mr. KILGORE. I would be interested in some of the physical aspects of installation—antenna height and that sort of thing. The question the chairman has raised about the matter of stability on a vessel. The gyroscopic techniques that undoubtedly have been developed that indicate its feasibility and those things. Perhaps they ought to be developed also in executive session, I don't know.

Mr. GARDNER. Yes.

If we could have time to answer the questions in executive session, it would be better.

If you cared to see some of the installations, we could gain the transferral of that information to you, with an actual observation of the physical facts.

Mr. HOLIFIELD. I think the committee would like to do that. We will see if we can set a time which is agreeable.

Can you bring a plane to Washington to show it to us? It is not necessary for us to leave Washington for that, is it?

Mr. GARDNER. No, we can have the plane here.

Mr. HOLIFIELD. Were you through with your questions, Mr. Kilgore?

Mr. KILGORE. I think so. There are any number of those things I wanted to go into.

Mr. HOLIFIELD. Mr. Fascell——

Mr. FASCELL. I'll pass over my questions for the time being.

Mr. HOLIFIELD. Mrs. Griffiths, you wanted to come back to Commander Laub.

Mrs. GRIFFITHS. I wanted to ask about the state of the contracts. Your contracts are open end contracts where you can go back and have the manufacturer make additional changes in equipment that has already been delivered, can't you?

Commander LAUB. The answer is this: If those changes are over and above the equipment specification requirements then it would cost us to get those changes made, but if those changes are deficiencies with respect to the performance of the equipment, as against the equipment specification, then the contractor would have to make the changes.

Mrs. GRIFFITHS. But you are accepting delivery on equipment that you anticipate, now, when you accept it, will have to be changed.

Commander LAUB. Very little. The first four hundred we did but we got them to find out some of the answers with respect to the use and reliability and they have been used and the information that has been obtained from them has been reinserted into these equipments that are now being built and have been used to obtain reliability information.

The one point I think that is important is that you have to have production equipment before you can check the reliability. In other words, it does little good to take a development model and try to prove reliability on that because it is not representative of production techniques. You cannot prove reliability on development models. You can get an indication, but your final proof is actually on production models which can be sent through the proper test to determine what reliability they have. Based on this knowledge, then you incorporate the changes.

Mrs. GRIFFITHS. These are really developmental contracts, so to speak. They are things that other services are calling production contracts.

Commander LAUB. I think Mr. Gardner answered that question. He said this is true of essentially everything we buy. The last equipment we build, we will probably be making changes in it. It is an improvement, really.

Mr. HOLIFIELD. Are there any further questions.

Mr. FASCELL. Somewhere along the line on all of this problem you have to turn research into production and I assume in the chronological statement you submit you will advise when that was done in this case.

Mr. GARDNER. When the actual research was stopped.

Mr. FASCELL. When R. & D. was turned into production.

Mr. GARDNER. We can tell you when production was initiated. We cannot tell you when development will stop.

Commander LAUB. In the summary I indicate the date of the production contracts for the airborne and the ground equipment. That probably is about the best information.

Mr. HOLIFIELD. We recognize that improvement always takes place and it should take place, but I think without getting too technical you recognize the difference we place on research and development and actual line production of items, always with a view, of course, that they can be changed under the terms of your contract. You either have to pay more, or they have to be changed to bring them up to your specifications.

Mr. GARDNER. If you look back through the mirror, you have to put some depth in it and put a little curve of national fear and fever beside the decisions because the place where you decide to go into production is directly in proportion to the degree of national fever, or very close to it.

Mr. HOLIFIELD. I think we recognize that factor.

General Blake, you are next on the list, now. Do you have a prepared statement or do you have anything that you wish to add to the statements that have been made, at this time?

General BLAKE. I didn't realize I was next on the list, Mr. Chairman, but I'll be responsive to your questions.

Mr. HOLIFIELD. You have no statement to volunteer to fill in any gap that you feel may have been left in the testimony?

STATEMENT OF MAJ. GEN. GORDON A. BLAKE, DIRECTOR OF COMMUNICATIONS, DEPUTY CHIEF OF STAFF, OPERATIONS, UNITED STATES AIR FORCE

General BLAKE. Perhaps it is important to address one remark to the reference to 10 years. The ANDB plan of action, if it delivered TACAN equipment capable of delivering distance information in anything like the time schedule suggested by the other witnesses, it would be, I think, far short of 10 years. The 10 years is with reference, Mrs. Griffiths, to the time we would be continuing to use VOR as a phaseout while you are phasing in TACAN. I don't believe it is contemplated that either the military services or the several users of the airspace would be without distance information for anything like 10 years. The immediate sacrifice of distance information seems to be one of the cheapest prices that can be paid in order to get this common system back on the track.

With respect to one other question, it might be well to note that the majority view on the VORTAC Committee represented a significant portion of the users of the airspace in terms of those who operate aircraft. I would estimate it is about 80 percent represented by the scheduled airlines and the military services.

Mr. HOLIFIELD. You must enlarge the field of the scheduled airlines to the commercial users, would you not?

General BLAKE. Oh, yes.

Mr. HOLIFIELD. You didn't mean that the commercial users and the scheduled airlines, and even the nonscheduled lines, would amount to about 20 percent, is that what you meant?

General BLAKE. It is my understanding that the military services represent about 40 percent of the IFR postings—I received a note saying it is over 80 percent. I was about to say 40 percent to the military services and the IFR—this is flights posted while conducting instrument flights—40 percent for the scheduled airlines and the other 20

percent being the nonscheduled airlines, the private fliers, and so forth. I don't mean to minimize the other 20 percent, but there is a significant portion of the users of the airspace who are on the majority side.

Mr. HOLIFIELD. I think it is important for us to know that.

Are there any questions of General Blake? Mrs. Griffiths, did you have another question?

Mrs. GRIFFITHS. No, Mr. Chairman.

Mr. HOLIFIELD. We want to thank the witnesses for their testimony. This will give us a little home study to try to digest what you have given us, today.

Mr. FOGLER. I think a casual reading of the testimony that has been given there today might indicate that TACAN is a failure. Now, TACAN is not yet a complete success, but planes are operating with TACAN, and Mr. Gardner and some other people are going to show you that that happens.

Mr. HOLIFIELD. If you gentlemen have anything to say that the press can pick up, now—you have left yourselves in a very bad hole by saying you are going to testify on reliability in executive session, so if you want to stay in the hole it is all right with me.

Mr. FOGLER. I think the better term is "serviceability," rather than "reliability."

We must keep in mind that the military services have a mission of urgency and we do have a tremendously difficult problem, something that I knew nothing about in civilian life, and that is to make this decision which has been commented on, as to where procurement starts from a production line. Not a hand-built model.

In connection with those that have been ordered, we have to relate those numbers to the tremendous numbers of planes which are in operation by the Air Force and the Navy, and it is very much smaller than the total number of planes in operation. It is a relatively small production that has been contemplated. It involves a lot of dollars, because these defense items are expensive, unfortunately.

Mr. HOLIFIELD. Mr. Gardner——

Mr. GARDNER. We are prepared to offer the documents that Mr. Quarles offered this morning, at this time, sir.

Mr. HOLIFIELD. Then we will notify you gentlemen when it will be mutually convenient for us to have an executive session.

Thank you very much and I will accept those documents.

The subcommittee is adjourned.

(Whereupon, at 3:25 p. m., the subcommittee adjourned to reconvene at the call of the chairman.)

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